WORLD ANIMAL REVIEW

21

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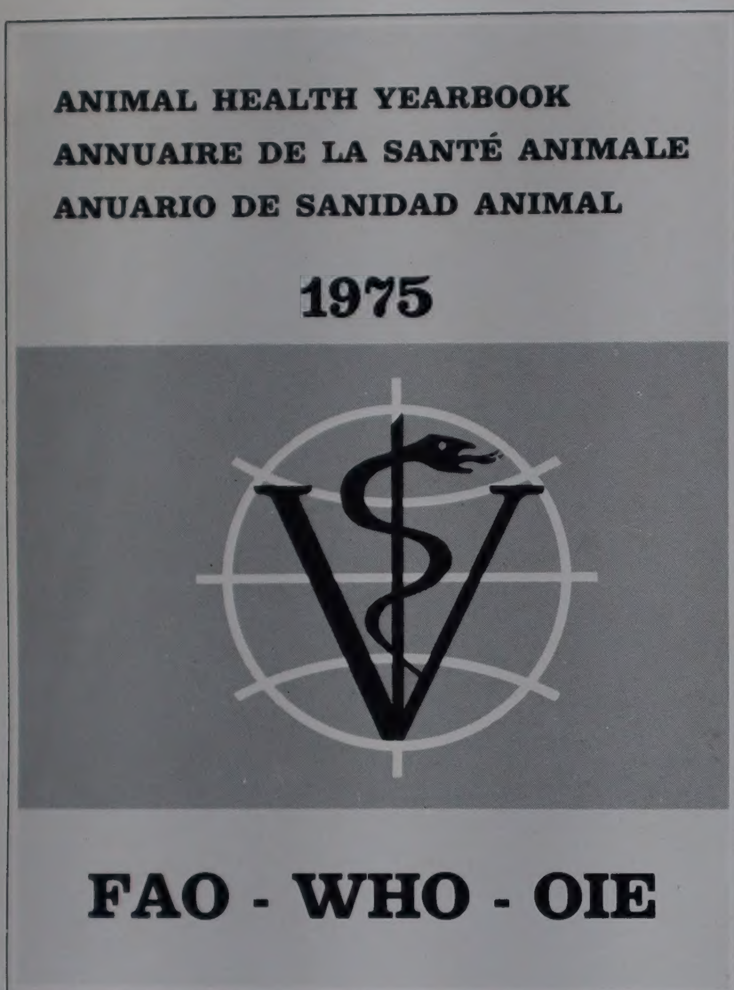
A QUARTERLY JOURNAL DEVOTED TO WORLD DEVELOPMENTS IN ANIMAL PRODUCTION, ANIMAL HEALTH AND ANIMAL PRODUCTS

ANIMAL HEALTH YEARBOOK 1975



ANIMAL HEALTH YEARBOOK 1975 contains detailed information on the occurrence, distribution and control of several hundred animal diseases in virtually all countries of the world, statistical data on livestock populations and the number of veterinarians in these countries, and a summary of changes in the livestock disease position in 1975.

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COVER: Capybara in Venezuela. (Photo: E. González Jiménez)

The role of animal productio

In a world already suffering from widespread malnutrition and indeed facing large-scale starvation in the years to come, crucial decisions regarding the orientation of protein production must now be taken by development planners.

Because of a combination of consumer preference, price elasticity and rising income, there is at present a rapidly increasing demand for animal products throughout the world. As such products are favoured by the public, the amount spent for their purchase tends to increase in proportion to the average disposable income, which is now rising in many regions. However, animals are not very efficient feed converters. About 8 to 10 kg of feed are required to produce one kg of live weight gain in beef animals or lambs (which represents only about 0.5 kg of carcass). Pigs and laying hens offer a 50 percent better conversion rate (about 5 kg of feed per kg of live weight produced), while broilers can be raised on as little as 2.5 kg of feed per kg of live weight. However, in monogastric animals (pigs and poultry) the better conversion rate is somewhat offset by the higher quality of the feed required. Therefore, these domestic species are to some extent in competition with man for edible foodstuffs.

A much cited example of the "wastefulness" of livestock production is the feeding of cereal grains to cattle for beef production. In the developing world, grain production/consumption averages approximately 182 kg per person per year. In the developed world average consumption reaches 910 kg per year (five times the amount consumed in the developing countries) of which 90 percent is consumed indirectly, as it is fed to animals and converted into high-protein value animal products such as meat, dairy products, eggs, and some non-edible products such as wool, hides and skins (Brown, 1974). The grains fed to animals in the industrial countries could provide subsistence rations to, or complement the inadequate diet of, numerous undernourished people in the developing countries. Obviously, this apparently iniquitous situation is likely to give rise to an increasing outcry against the use of valuable cereal grains for the production of what is considered in the developing countries as luxury products.

Should then the production of animal proteins be discouraged or even banned, making the fulfilment of mankind's future nutritional needs entirely dependent on the promotion of vegetable products? It is indeed feasible to devise a purely vegetarian diet sufficient to ensure human survival and subsistence. However, before adopting such an extreme, though understandable, attitude, a number of factors should be considered.

High-value protein

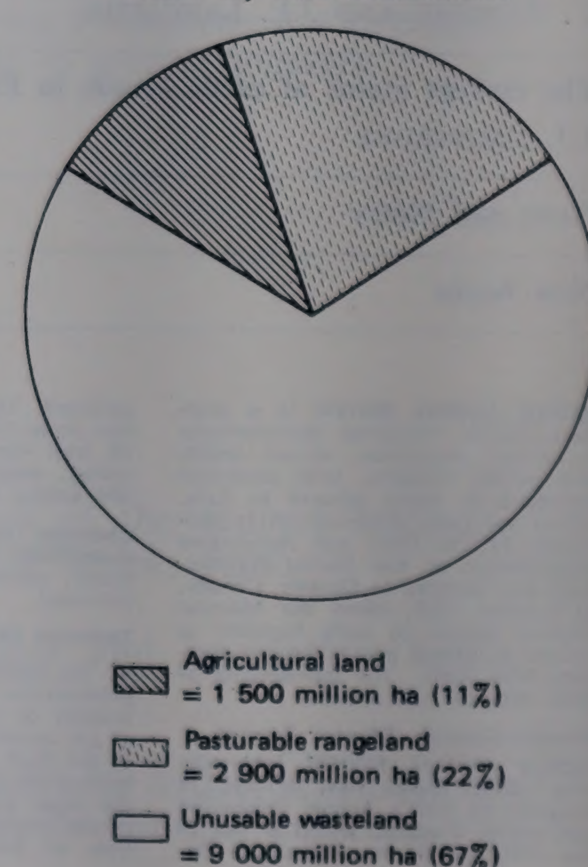
Food products of animal origin are richer in high-value protein, both in quality and quantity. Vegetable proteins are labelled as "incomplete proteins," which means that they are lacking in one or more of the amino acids which are essential for normal growth, and that they are far less assimilable by the human body. For instance, maize proteins are only 53 percent assimilable; in comparison, eggs have a net protein utilization rate of 94 percent, milk 82 percent and beef 73 percent (Bogert *et al.*, 1973). However, through judicious combinations of vegetable species and the addition of synthetic amino acids, vitamins and minerals, it is theoretically possible to create a biologically balanced human ration. Nevertheless, the bulk of such a ration will be rather excessive if it is to satisfy all the needs in energy (calories), total nutrients and proteins.

Conversion of inedible feeds and products into edible proteins

Ruminants (cattle, sheep, goats and camels) are capable of digesting and converting into proteins consumable by man a number of feeds and products which humans cannot eat, such as:

1. *Forages from natural grasslands.* The most recent global land availability surveys show that of the total

Global dry land availabilities



Frank P. Vandemaele *is senior technical adviser with the Technical Advisory Division, United Nations Development Programme, One, United Nations Plaza, New York, N.Y. 10017, United States.*

n world agriculture

by Frank P. Vandemaele

dry land surface of the earth (13 400 million hectares), about 67 percent (about 9 000 million hectares) should be regarded as total wasteland because of insufficient rainfall and other unfavourable conditions. Of the 4 400 million hectares (33 percent of the total dry land surface) suitable for agriculture, only 1 500 million hectares (about 11 percent of the total dry land area) can be cultivated. The remaining 2 900 million hectares (about 22 percent of the total dry land surface) consist of natural grasslands (rangelands, savannas, steppe, brushland, scrubland, etc.) which are suitable only for grazing and browsing. Until such time as natural vegetation can be converted directly into edible human food, domestic and wild ruminants will remain the only means of utilizing these resources and converting them into protein-rich food acceptable to, and digestible by, man. Without them, these natural grasslands would have to be classified as totally unusable wasteland.

2. *Forage crops* (cultivated grass, legumes and other fodder crops, such as field maize and sorghum, elephant grass, etc.). These can be grown on land which is arable but less suitable for growing food crops.

3. *Unprocessed agricultural residues* such as stubble, straw, maize cobs and stovers, sugarcane tops and stalks, banana rejects, etc. which would otherwise be lost to human nutrition.

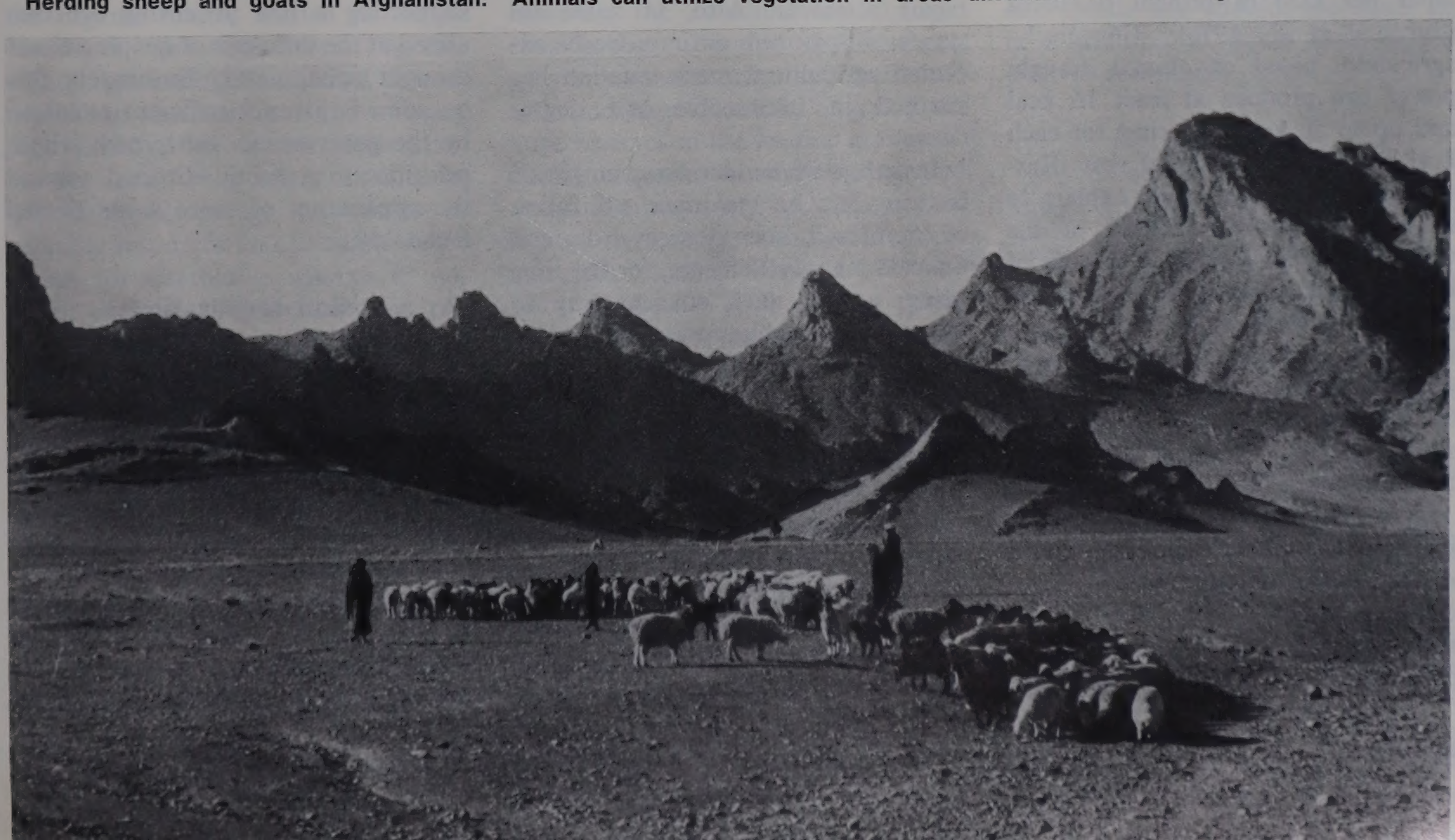
4. *Processed agricultural or industrial by-products* such as bran, cottonseed, groundnut meal, urea, molasses, bagasse, citrus pulp, cellulose wastes of paper pulp industries, slaughterhouse and fishery by-products, etc., all products which usually accumulate in agricultural and industrial concerns but which can usefully be disposed of by feeding them to animals as part of a productive ration. Alternatively, these by-products can be fermented by yeasts and other microorganisms to yield single-cell protein, which is then processed into livestock feed.

5. *Fishmeal* derived from fish and other marine animals (e.g. fish waste, Peruvian anchovies, Antarctic krill) which are unpalatable as direct human food. However, the economics of catching, processing and transporting this material may make this approach rather extravagant. Furthermore, current research points to the possibility of converting these resources into purified fish protein concentrate which could be incorporated directly into human food products or rations.

Draught power

In many parts of the world, animals constitute the essential source of draught power for cultivating the land and harvesting and transporting its

Herding sheep and goats in Afghanistan. Animals can utilize vegetation in areas unsuitable for other agricultural activities.



produce to storage facilities and markets. The use of animal traction in daily life is now being decried as an undeniable sign of agricultural and economic backwardness, but it should be remembered that European and North American agriculture depended almost entirely on animal traction until well into the present century and achieved levels of productivity which many developing countries have not yet attained. Outright or wholesale substitution of animal draught power by fuel-powered mechanization is sometimes advocated, despite the fact that from an energy utilization and conservation viewpoint, modern mechanized food production is grossly inefficient. Indeed, fully mechanized farmers in the developed world have to put in approximately 2.5 kcal of costly and non-renewable fossil fuel for the production of each kcal of food. In terms of protein energy conversion, this ratio is even less favourable. In a modern, highly mechanized animal production system, 35.9 kcal of fossil fuel energy are required to produce 1 kcal of milk protein; 13.1 kcal are needed for 1 kcal egg protein; 22.1 kcal for broiler protein; 34.6 kcal for catfish protein; 35.4 kcal for pork protein and 77.7 kcal for beef protein from feedlot cattle. Proteins produced through beef animals on modern mechanized ranches still require 10.1 kcal of fossil fuel energy input per kcal of protein produced (Pimentel *et al.*, 1975). Conversely, agriculture based on animal draught power can produce at least 16 kcal and up to 50 kcal (e.g. rice) for each kcal of output at nominal cost (Ensminger, 1975). This could explain to a certain extent the fallacy of the widely accepted belief that because of the potential of intensive agricultural methods developed in the western world for increasing quantitative output, their indiscriminate application in the developing countries must necessarily result in reduced production costs and lower prices to the consumer.

This does not mean that there is no scope for improved agricultural technology in the developing world. Obviously, promotional efforts for better seeds, fertilizers, improved animal and plant health protection and more efficient agricultural equipment and management techniques must be vigorously pursued. However, the question of large-scale mechanization must be carefully reviewed in the light of rising costs and possible shortages of fossil fuel energy, as well as the difficulties of ensuring the sustained operation of sophisticated equipment through the creation of adequate maintenance and repair services. Also, in some instances ill-planned or improperly executed agricultural mechanization has resulted in irreversible soil degradation.

Students at the Kundasale School of Agriculture for Girls in Sri Lanka learn to use two bullocks and a disc harrow.

In an age where increasing emphasis is being laid on maximum utilization of non-fossil solar energy, draught animals may well emerge, for the time being, as the most efficient way to convert into usable power (with high-value proteins and organic fertilizers as a bonus) the continuously renewed energy stored by photosynthesis in the vegetation.

From a socio-humanitarian point of view, draught animals can also play a significant role in the betterment of the human condition in the developing world. In many parts of the world, some of the least developed societies are still entirely dependent on human labour for land cultivation. The toil and drudgery of these tasks are usually relegated to women, who are thus reduced to an inferior position in the community. In such primitive groups the introduction or promotion of animal draught power appears as a first and essential step toward improving the status of women. The United Nations Development Programme is currently supporting a few promising schemes aimed at the diffusion of simple animal draught techniques. Unfortunately, this question is given insufficient attention by the governments concerned, whose priorities are mainly directed toward the application of more sophisticated technologies.

Soil fertilization

In the same line of concern about energy conservation, the role of animals as a soil fertilization factor should not be overlooked. In the past few decades the availability of cheap fossil fuels and easily applicable chemical fertilizers has caused farmers all over the world to neglect somewhat the humble manure resources which are available on the farm at no cost but are unwieldy and unpleasant to handle.

However, the 200 to 300 percent increase in chemical fertilizer prices between 1972 and 1974 that was a corollary to the energy crisis has shattered the world's earlier belief that future agricultural development planning could solely and indefinitely be committed to the utilization of chemical fertilizers. This is particularly the case in areas where cost of production and consumer purchasing power are determining factors.

The current concern for pollution control also highlights the need for a more rational use of animal wastes. This is mainly the case for the large-scale industrial-type animal production units (feedlot finishing, pig and poultry production units) which are being created in increasing numbers in developing as well as developed countries. Apart from their utilization as regular organic soil fertilizers, the recycling and conversion of these wastes into animal feeds and/or fish pond fertilizer are now being studied.

Discussions on the question of organic soil fertilization cannot be complete without mentioning the deleterious practice of utilizing animal droppings as cooking or heating fuel. Because of increased costs of fossil fuels and injudicious deforestation, cow dung is being substituted for firewood with increasingly alarming frequency in large areas of the developing world. The soil is thus deprived of much of the organic matter needed to ensure continued vegetation cover. Together with ill-planned deforestation, it contributes to sterilization of the soil and, subsequently, irreversible desiccation of the land. No effort should be spared to discourage this waste of valuable resources and to continue the search for alternative sources of domestic energy. In this connection, relatively simple techniques have been developed recently for on-farm methane gas production through fermentation of animal wastes which can still be used as organic fertilizer after processing for fuel gas extraction (Preston, 1976).

Balanced food production systems

In the light of the above considerations, animals obviously have an important and well-defined role to play in a rational and balanced food production system. Actually, the question is not whether animal husbandry is an important item in modern agriculture, but how to maximize the utility of animals by enhancing their complementarity with, and integration into, crop cultivation and reducing their competitiveness with man for vegetable and other humanly edible resources.

Earlier in this article it was mentioned that the feeding of cereal grains to livestock has been stigmatized as a shameful squandering of potential food resources which could be more usefully dedicated to the humanitarian purpose of sustaining and improving human lives in the less favoured areas of the earth. It must be said, however, that the grain feeding practice mainly originated from the huge grain surpluses which in the two decades following the Second World War were filling the storage facilities in the leading grain-producing countries. In the rest of the world there were no surpluses during that period, but grain production was more or less able to keep pace with the growth of the population. Favoured by low prices and encouraged by overproduction and high consumer purchasing power, feeding, fattening and finishing of livestock provided a justifiable outlet for the utilization of non-exportable cereals in the surplus-producing countries. In recent years, however, the situation has changed considerably. Because of food shortages in some countries and their need to import large quantities of grains, the huge reserves in the leading grain-producing countries have now dwindled away. Consequently, and also as a result of the energy crisis, grain prices more than doubled between 1970 and 1974 (FAO, 1971-75). As a result, feeding cereals to animals has become less economic. Nevertheless, the purchasing power in the affluent countries still matches the rising prices of livestock production based on grain feeding. It is anticipated, however, that, by the sheer play of the laws of economics, livestock production practices based on grain will gradually have to be substituted by other methodologies and technologies which are more adapted to the changing realities of our times. For example, the U.S. Department of Agriculture has recently inaugurated a new meat grading system whereby lean (i.e. less- or non-grain-fed) meat is being upgraded to "choice quality," a grade which was previously reserved for marbled (high fat content) meat produced mainly by grain feeding.

It is hoped that the conscience of the industrialized countries will increasingly awaken to the morally dubious incongruity of feeding to animals food resources which might, in the foreseeable future, be desperately needed to save human lives in the less favoured countries. For the same reason, it might also soon become objectionable to dedicate to the production of animal feeds large tracts of land suitable for growing human food crops.

Conclusion

It would thus appear that livestock production will depend increasingly on the utilization of non-humanly consumable feedstuffs. Fortunately, there are many different agricultural and industrial wastes and residues that are unacceptable to or indigestible by man which can be incorporated in productive animal rations with minimal impingement on the availability of the world's increasingly needed food resources. Livestock development planners should be aware of these facts and trends and should, therefore, be in a position to direct development policies accordingly.

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Resource costs of animal

by J. Krummel and W. Dritschilo

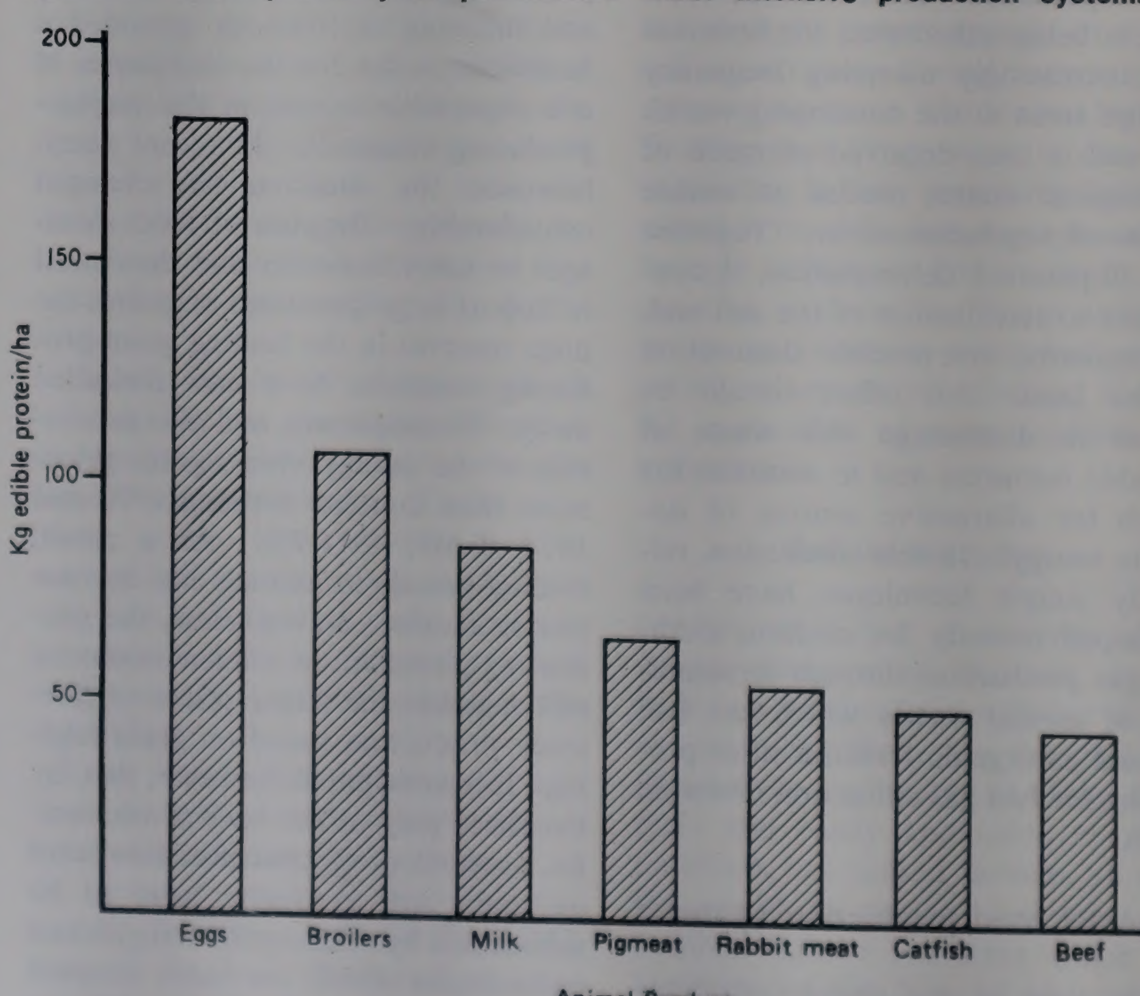
The limited availability of arable land and fossil energy and deficiencies in managerial capacity and investment opportunity constitute serious problems in world food production. Such resource shortages, aggravated by overpopulation and environmental decay, require an evaluation of our food production techniques to ensure adequate diets for future generations. The present world population of 4 000 million is expected to increase to 7 000 million by the year 2000 (National Academy of Sciences, 1971). Nearly 500 million persons now face food protein and energy shortages, and thus an approach to food production combining resource assessment and effective management is desirable. An input/output analysis of food production systems, based on protein and energy yield per unit of resource used (land, labour, fossil energy), permits a comparison of production systems that is a necessary alternative to a strict economic approach to any management decision.

In combination with detailed economic analysis, an ecological investigation of agricultural systems can provide a clear picture of the resource costs of food production. Ecological knowledge of the amount of land and fossil energy resources used in agricultural production systems can play a vital role in designing alternative resource management strategies. As ecologists we are concerned with the resource and energy inputs of ecosystems.

The modern agro-ecosystem depends upon non-renewable and limited amounts of fossil fuel energy and a finite land area. Fossil fuel energy and land inputs are therefore as important as yield in production systems. Although yield should be maximized, this must be accomplished with full knowledge that land and fossil fuel energy may be critically taxed in the near future. Ecological accounting of energy inputs and outputs provides a clear interpretation of the mechanisms involved in a food production system.

Economics remains a prime component of decision-making. By using energy accounting that assigns projected prices for the kilocalories of energy input and food output, a sound base for economic decision-making can be arrived at. As fossil fuel prices continue to rise and the effects of land degradation continue to deplete arable land, management decisions will have to be based on

Figure 1. **Edible protein yield per hectare under intensive production systems**



SOURCE: Westoby et al., 1976.

J. Krummel *and* W. Dritschilo *are at the College of Agriculture and Life Sciences, Cornell University, Ithaca, N.Y. 14850, United States.* *The authors acknowledge helpful comments from David Pimentel and Mark Westoby and the support of a Ford Foundation grant during the preparation of this article.*

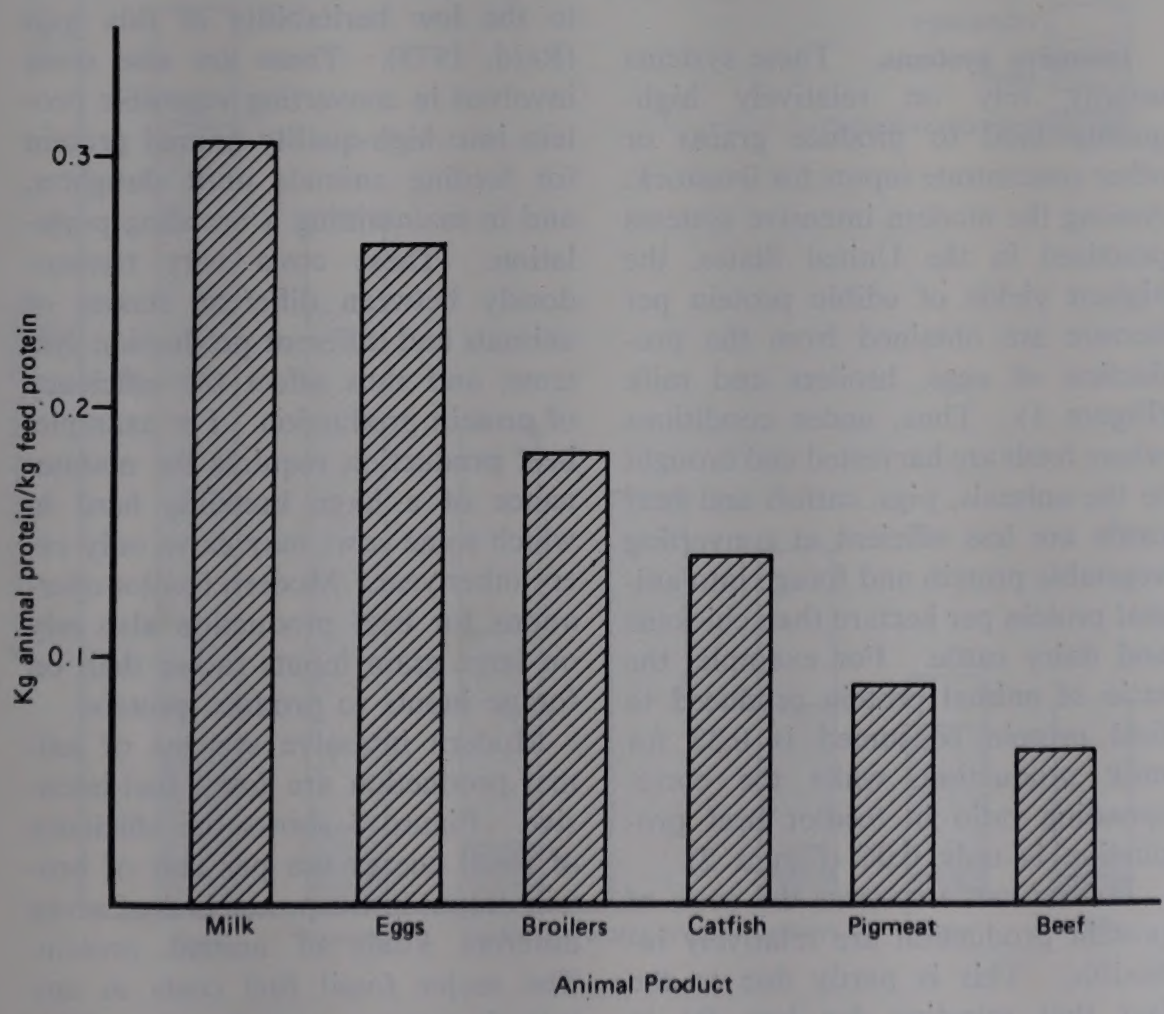
rotein production

the resources required to produce a given food product. An ecological and economic approach will be especially helpful in managing the critical agricultural resources of land and energy during the next 25 years.

With protein and energy deficiencies affecting many areas of the world, it seems desirable to analyse various methods of animal protein production. At present, animal production accounts for 25 percent of the world's protein needs (Pimentel *et al.*, 1975). The animals consume an estimated 17 percent of the world's total vegetable protein. In the United States 24.6 million metric tons of an estimated 27.1 million metric ton total output of cereal, legume, and vegetable protein is fed to livestock. As world population continues to increase, pressure will develop on world agriculture to produce enough protein to feed a hungry world.

Energy, land, and labour are necessary inputs in any animal production system. These three inputs are interrelated, and within limits can be substituted for one another. Through large inputs of fossil fuel, the amount of labour required to produce a given protein yield can be reduced. The amount of land needed to produce a given protein yield can be reduced by increasing the intensity of land management through the energy inputs associated with irrigation, fertilization, and mechanization. The impressive yields of modern agriculture are in large part a function of the role of fossil fuel in food production. Through a reduction in the land and labour inputs needed to produce crop and animal products, a large number of non-farm workers can be fed. However, critical shortages of fossil fuel will develop in the next 25 years if present rates of consumption continue (Hammond, 1972). The role of fossil fuel in animal production systems will become crucial as shortages of this resource develop.

Figure 2. **Ratio of animal protein to ingested feed protein under intensive production systems**



SOURCE: Westoby et al., 1976.

Animal production systems

Many animal production systems tend to aggravate the competition for food between man and animals (Reid, 1973). In the United States, for example, for every 5 kg of vegetable and fish protein fed to livestock (in addition to a large forage intake), only 1 kg of animal protein is produced (Pimentel *et al.*, 1975). Table 1 shows a comparison of forage crops and grain crops used as feed in animal production systems. Forage crops are generally higher in food energy yields per fossil fuel input than grain crops. For example, according to our estimates, the ratio of food energy yield to fossil energy input is 3.79 for forage crops (alfalfa, maize, silage, hay) while the energy ratio of grain crops (maize, oats, wheat) is 2.39. Forage crops have lower energy costs per unit of yield

Table 1. **Analysis of vegetable protein production per hectare for various crops in the United States and elsewhere requiring different amounts of labour and energy**

Crop	Crop yield in protein	Crop yield	Crop yield in food energy	Fossil energy input for production	Labour	Fossil energy input/protein output
	...... kg		..... 10^6 kcal		man-hours	kcal
Alfalfa	710	[2] 6 451	11.4	2.694	9	0.96
Soybeans	640	1 882	7.6	5.285	15	2.06
Maize	457	5 080	17.9	6.644	22	3.63
Maize silage	393	30 200	24.1	5.493	25	3.49
Dry beans [1]	325	1 457	5.0	4.478	15	3.44
Oats	276	1 900	7.4	2.978	6	2.70
Wheat	274	2 284	7.5	3.770	7	3.44
Hay	200	[2] 5 000	8.6	3.115	16	3.89
Maize (Mexico)	175	1 944	6.8	0.053	1 144	0.08
Rice (Philippines)	111	1 654	6.0	0.582	576	1.31
Wheat (India)	99	821	2.7	0.256	615	0.65
Sorghum (Sudan)	99	900	3.0	0.079	240	0.20

SOURCE: Pimentel **et al.**, 1975.
[1] The inputs include about 1.1 million kcal for processing the beans to make them edible for livestock. — [2] Dry.

because all of the above-ground primary production is harvested. However, protein production per hectare is similar for both forage and grain crops, with the exception of alfalfa. The ratio of kcal fossil energy input to kcal protein output is also similar. Thus maize silage and hay have ratios of 3.49 and 3.89 respectively, while maize and wheat have ratios of 3.63 and 3.44 respectively. Some crops such as alfalfa would require considerable energy inputs to extract protein usable by man; many crops are also deficient in certain amino acids. Maize, for example, is deficient in lysine and must be supplemented by other protein sources in the diet. But grains have a more concentrated protein yield than forage crops, and can be directly utilized by humans. Using grain as animal feed removes humans another step from plants, the primary producers of protein, and decreases the total protein that would be available if the grain were consumed directly by humans.

Animal protein production can be conveniently divided into intensive and extensive systems.

Intensive systems. These systems usually rely on relatively high-quality land to produce grains or other concentrate inputs for livestock. Among the modern intensive systems practised in the United States, the highest yields of edible protein per hectare are obtained from the production of eggs, broilers and milk (Figure 1). Thus, under conditions where feeds are harvested and brought to the animals, pigs, catfish and beef cattle are less efficient at converting vegetable protein and forage into animal protein per hectare than chickens and dairy cattle. For example, the ratio of animal protein produced to feed protein consumed is 0.32 for milk production, while the corresponding ratio in feedlot beef production is only 0.06 (Figure 2).

In beef cattle systems the costs of protein production are relatively inflexible. This is partly due to the fact that selection for low fat in cattle (i.e. for a higher proportion of body weight in protein) is slow owing to the low heritability of this trait (Reid, 1973). There are also costs involved in converting vegetable protein into high-quality animal protein for feeding animals until slaughter, and in maintaining a breeding population. These costs vary tremendously between different classes of animals and different production systems, and thus affect the efficiency of protein production. For example, beef production requires the maintenance of a large breeding herd in which some cows may calve only every other year. Modern feedlot operations for beef production also rely on large grain inputs rather than on forage inputs to produce protein.

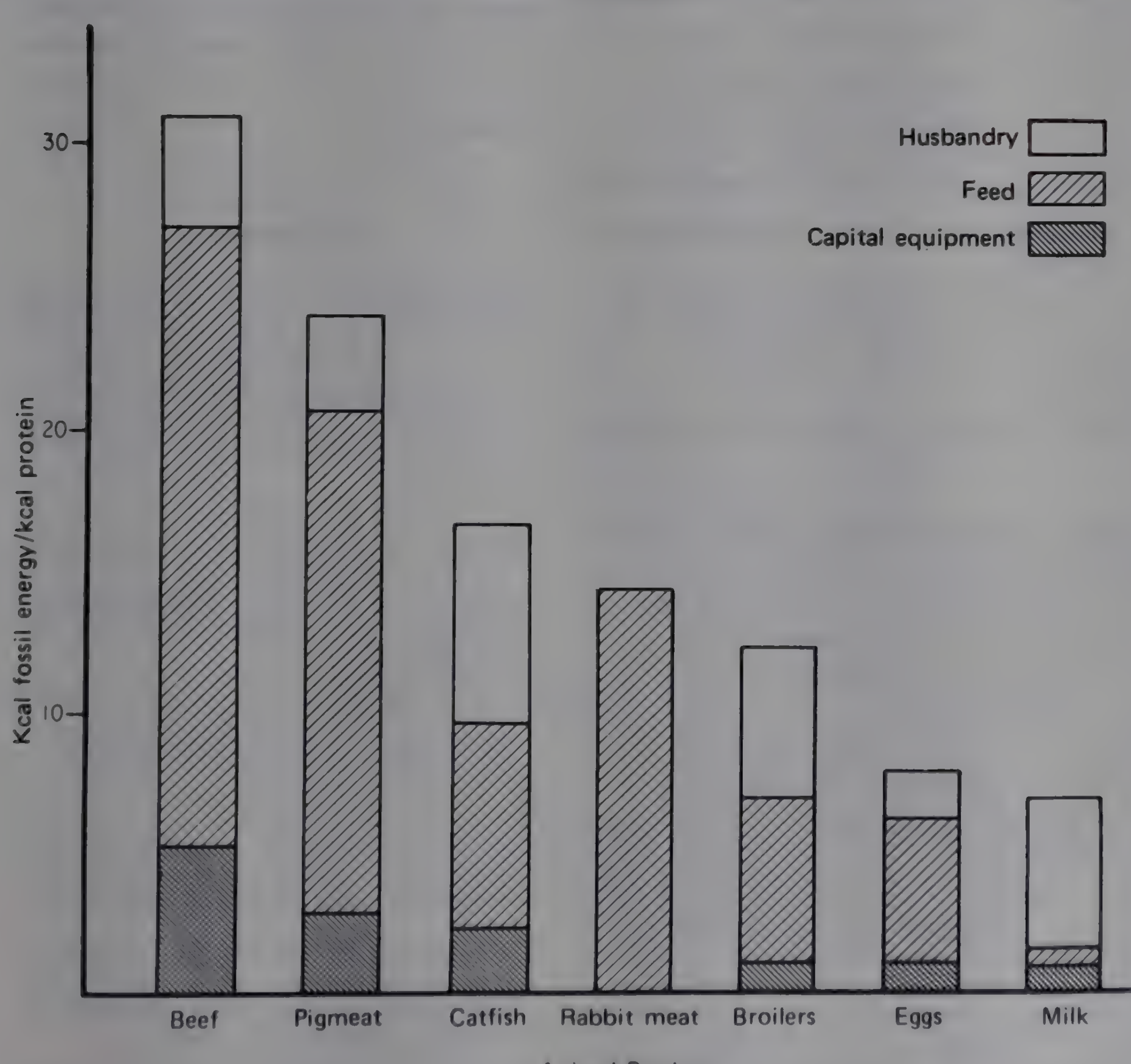
Modern intensive systems of animal production are fossil fuel-intensive. Figure 3 shows the efficiency of fossil energy use per unit of protein output in the production of seven different kinds of animal protein. The major fossil fuel costs in any intensive system are a function of the

feed input of the system, although husbandry operations also require a considerable fossil fuel input. Milk and egg production are the most efficient protein producers for a given fossil fuel input. United States beef production is the most energy-intensive system, mainly owing to the large amount of grains used to fatten the animals for market. Sixty percent of the total energy used in feedlot beef systems is associated with the production of feeds. Of the remaining energy used in intensive beef production, almost one half is associated with producing capital equipment and buildings — the highest of any system studied. Pig production also involves large energy inputs for producing feed, with smaller amounts for husbandry and capital equipment. Milk production, however, uses very little fossil fuel for feed inputs, and most of the energy is used for husbandry operations. Rabbit production in the United States is a "backyard affair" and uses negligible amounts of energy for husbandry and capital equipment.

Extensive systems. Modern range systems of animal protein production are less efficient than intensive systems in terms of total land use (Table 2). In the extensive systems the economy of land use is a direct function of the quality of the land that is utilized. For example, the cow-calf systems range from 45 to 370 hectares per 100 kg of protein yield. These systems are subject to the vagaries of rainfall patterns, and the most productive rangeland is that which receives the largest amount of rain. In the Australian sheep systems the pastoral zone (an area of low rainfall) uses 535 hectares, the wheat/sheep zone uses 36 hectares, and the high rainfall zone uses only 12 hectares for each 100 kg of protein yield.

Nomadic systems of protein production can often, with no input of fossil fuel, make highly productive use of land of very poor quality (Table 3). The Chukchi, who herd reindeer in the Siberian tundra, achieve yields almost equal to some of the modern cow-calf and sheep production systems. The Karamojong, in fact, achieve higher yields by herding small stock and cattle than any of the modern United States cow-calf operations. These tribal herding systems exploit animals more efficiently (milk and meat) than modern operations, although some of the nomadic systems probably also reflect conditions of overstocking. For example, the Karamojong increased their stock by 470 percent from 1922 to 1953-55, partly as a result of improved veterinary care and partly owing to the nomadic belief that cows represent wealth (Dyson-Hudson and Dyson-Hudson, 1970). The relatively high yields of some of the nomadic systems have been accomplished, however, with a labour cost that would be uneconomic in western societies. Indeed, there is little excess protein for export due to the high labour inputs. The protein produced by the animals must be consumed by the owners and their dependants who look after the animals. Modern rangeland systems, although incapable of increasing the protein output of the land used, are capable of greatly decreasing the labour expended to produce this protein. This decrease in labour input frees excess food for use in trade for other commodities.

Figure 3. **Amount of fossil energy input per kcal of animal protein under intensive production systems**



SOURCE: Westoby et al., 1976.

Increasing the efficiency of animal production systems

As agricultural resources, especially fossil fuel reserves, become increasingly scarce, more efficient means will have to be found to produce animal protein. Animal production methods that maximize protein output for a given feed input must be developed. This results in minimal costs for maintenance in comparison to the growth achieved. One way of doing this is to select for high prolificity but small size in dams, and for rapid growth rates in progeny. The interval between parturition and subsequent conception should be mini-

Table 2. **Protein production, fossil fuel input and labour for some modern intensive animal range systems**

System	Protein/hectare	Protein energy/fossil fuel energy	Protein/man-hour
	kg	*kcal*	*kg*
Beef (United States)			
Texas cow-calf	2.23	0.21	2.163
New Mexico cow-calf	0.273	0.081	0.69
Northern plains cow-calf	2.52	0.1	0.711
Rocky Mountain cow-calf	1.25	0.126	0.81
Louisiana cow-calf	0.605	0.12	0.79
Lamb (United States)			
Utah	0.17	0.07	0.44
Utah and Nevada	0.66	0.135	0.34
Sheep (Australia)			
Pastoral zone	0.187	0.025	0.94
Wheat/sheep zone	2.75	0.04	0.516
High rainfall zone	8.14	0.15	0.63

SOURCE: Westoby **et al.**, 1976.

mal, as in the case of pig production where the sow can become pregnant after weaning and thus produce two or more litters per year. The reproductive life of the animals should commence when they are still young, and the progeny utilized as early as possible. In this context it should be noted that the production of chicken eggs is more efficient than the production of calves, piglets, or lambs because the latter must be fed before they can be utilized. Similarly, food should undergo the fewest possible metabolic conversions as efficiently as possible; the production of milk and eggs is more efficient in this respect than the production of meat products from pigs, beef cattle, or poultry.

Finally, conversion of feeds into protein should be accomplished by using forages rather than grains, since grains contain protein that can be directly utilized by man. Beef cattle, dairy cows and sheep are capable of using forages that are unavailable for human consumption and converting these feeds into utilizable protein. Dairy cows are also capable of producing as much as 3 600 kg of milk per year on an all-forage diet (Reid, 1973). Pigs, chickens and catfish, however, consume grains and other high-energy feeds that lower the overall volume of protein production.

The use of polygastric animals on rangeland, which comprises 22 percent of the land area of the world (FAO, 1973), allows man to utilize primary production that would otherwise be unavailable for human consumption. Such rangeland is generally unproductive as cropland, and would need large and possibly prohibitive inputs of fossil energy to produce crops suitable for man. In the United States, if a change were made to only grass-fed livestock, livestock protein production would decline from the present 6 million metric tons to an estimated 2 million metric tons (Pimentel *et al.*, 1975). Beef cattle, dairy cows and sheep can convert forages grown on such land into protein, leaving more productive areas to grow crops for direct human consumption.

Table 3. **Protein production and labour input of some pastoral animal systems**

System	Protein/hectare	Protein/man-hour
	. . . . *kg*	. . . .
Bassari	0.38	0.059
Rivala	0.13	0.031
Dodos	0.76	0.022
Karamojong	3.539	0.022
Chukchi	0.131	0.143
Cuene	0.896	0.025

SOURCE: Westoby **et al.**, 1976.

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A strategy for cattle production in the tropics

by T.R. Preston

Technologies developed in the temperate countries for production of milk and beef as independent specialized systems are not appropriate to the needs of developing nations in the tropics.

Instead, a multi-purpose approach based on combined production of milk, beef, fuel and fertilizer in a single integrated unit could improve the level of nutrition of the population as a whole and contribute to savings of foreign exchange.

The objectives in developing animal production systems in the tropics embrace a number of factors. These can be listed as follows:

1. Production of meat and milk, which in turn will improve the level of nutrition of the population as a whole, satisfy the demand for quality products by the sector of the population with adequate purchasing power, and lead eventually to exports.
2. Save and/or earn foreign exchange.
3. Create more employment, particularly in rural areas.
4. Improve the quality of life by reducing pollution and providing a balanced strategy of development which takes into account ecological factors.
5. Contribute to regional development.
6. Develop systems that are biologically, economically and ecologically appropriate for the country concerned.

This is a long list, but it is important to take account of all of these factors when planning a livestock development strategy. There have been too many examples of development which set out to satisfy only one or two of these objectives, with the result that the overall gain to the country concerned has often been minimal.

An example of unbalanced development is provided by Taiwan (China). In the past 15 years, livestock development has proceeded at a rapid rate to the point of self-sufficiency in pig and poultry products. Yet this self-sufficiency has only been brought about by a corresponding increase in imports of cereal grains and protein meals, from negligible quantities in 1962 to some 1 million tons of grain and 600 000 tons of soybean meal (worth about U.S.$ 300 million) in 1971. Livestock development in Trinidad and Tobago has had a similar history. As efforts were concentrated on the development of non-ruminants at the expense of increasing imports of raw materials (mainly feeds), the net effect of the livestock development programme on the overall balance of payments was found to be close to zero (Cropper, 1974).

Because so many mistakes have

T.R. Preston *is with the Centre for Livestock Research (Centro de Investigación y Experimentación Ganadera), Chetumal, Mexico.*

been made in the past, it is all the more important to weigh the various alternatives before deciding on a blueprint for livestock development in the tropics. An integrated approach is needed because errors have frequently been made when development is pursued on a piecemeal basis. Even in 1976 it was still possible to read in reports from international agencies statements such as "This proposal refers only to beef production since the development of a milk industry was the subject of an independent study," or "No plans are contemplated at this stage for the utilization of the male calves." The latter example is drawn from an investment plan for setting up a large-scale milk production scheme in an African country.

Of course, the most fundamental question is: Why has livestock development been so retarded in the tropics, and why has it not kept pace with that in the temperate countries? Is it because the tropics are not really suitable for livestock, or are there more basic reasons underlying the apparent lack of progress in animal production in these regions?

This article attempts to show that the tropics, far from being unsuitable for livestock development, offer a potential for productivity per unit area and an economic viability which far surpass the present or even future prospects of the temperate countries. The thesis is that the retarded development of livestock in the tropics reflects not lack of potential, but simply the fact that the research inputs required to develop an appropriate technology for these areas have never been provided on an adequate scale. The emphasis is on the word "appropriate" because, as will be made clear in this article, the nature of the feeds, the type of cattle and the management systems all differ materially from those which have been developed in the temperate world.

The need for planning

The first step in working out an appropriate technology for livestock development in the tropics is planning. Decisions are required as to the most appropriate animal species, feed resources and management systems.

Choice of animal species. Of particular relevance, when it comes to selecting an animal species, is the fact that in most tropical regions there may be quantitative, and almost certainly qualitative, shortages in the human diet. Competition between animals and humans for the same basic nutrients then poses a problem in resource utilization that must be taken into account.

For planning purposes, domesticated animals can be divided into the two broad categories of ruminants and non-ruminants. The latter have the same digestive system (and therefore similar nutrient requirements) as humans. The former possess an additional compartment in the stomach — the rumen — through which all solid foods pass, and where predigestion takes place by anaerobic fermentation. Because of this latter feature, the ruminant has the capacity to both degrade (digest) and use for synthetic purposes substances which are not usable by man. In this sense, they need not compete for available feed supplies. If they do compete, it is probably a result of bad planning and/or the application of "inappropriate" technology.

In marked contrast with the ruminant, pigs and poultry must nearly always compete with the human population for basic feed resources, especially cereal grains.

In nutritional terms, the special virtue of the synthesizing capacity of rumen microorganisms is their ability to transform inorganic ammonia nitrogen into microbial protein of excellent biological value — protein which subsequently becomes available to the host animal for formation of milk, meat and wool. The degrading properties of rumen microorganisms are used to advantage on feeds containing structural carbohydrates, chiefly cellulose and related compounds, for which the non-ruminant digestive system possesses no enzymes.

These two characteristics enable the ruminant to occupy a different ecological niche in comparison with the human; hence instead of competition, there can be true symbiosis between the two species. Thus, by transforming inorganic nitrogen and carbohydrate into animal protein (milk/meat), the ruminant will enable humans to live adequately in conditions where otherwise they would suffer protein deficiency.

The disadvantage of making the ruminant depend on simple nitrogen sources such as ammonia is that this in turn exerts a certain constraint on its rate of production. The efficiency of anaerobic fermentation in the rumen is relatively low, since there is only partial oxidation of the energetic components (as far as the volatile fatty acids). One result of this is that the amount of microbial protein that can be synthesized is determined by the amount of fermentable carbohydrate that is consumed. The second factor is that even at maximum voluntary intake levels, the actual amount of carbohydrate available for fermentation is not sufficient to allow the production of all the microbial protein needed to sustain high levels of animal productivity.

The importance of these relationships is illustrated in the graph, which shows the overall amino acid requirements of ruminants (expressed as daily retention of nitrogen), according to their productive state. The contribution of microbial protein to these requirements (as indicated by the dotted line) approaches adequacy only for late growth, early and mid-pregnancy and mid- and late lactation. Both fast growth in young animals and early lactation represent critical points when considerable supplementation with preformed protein will be required.

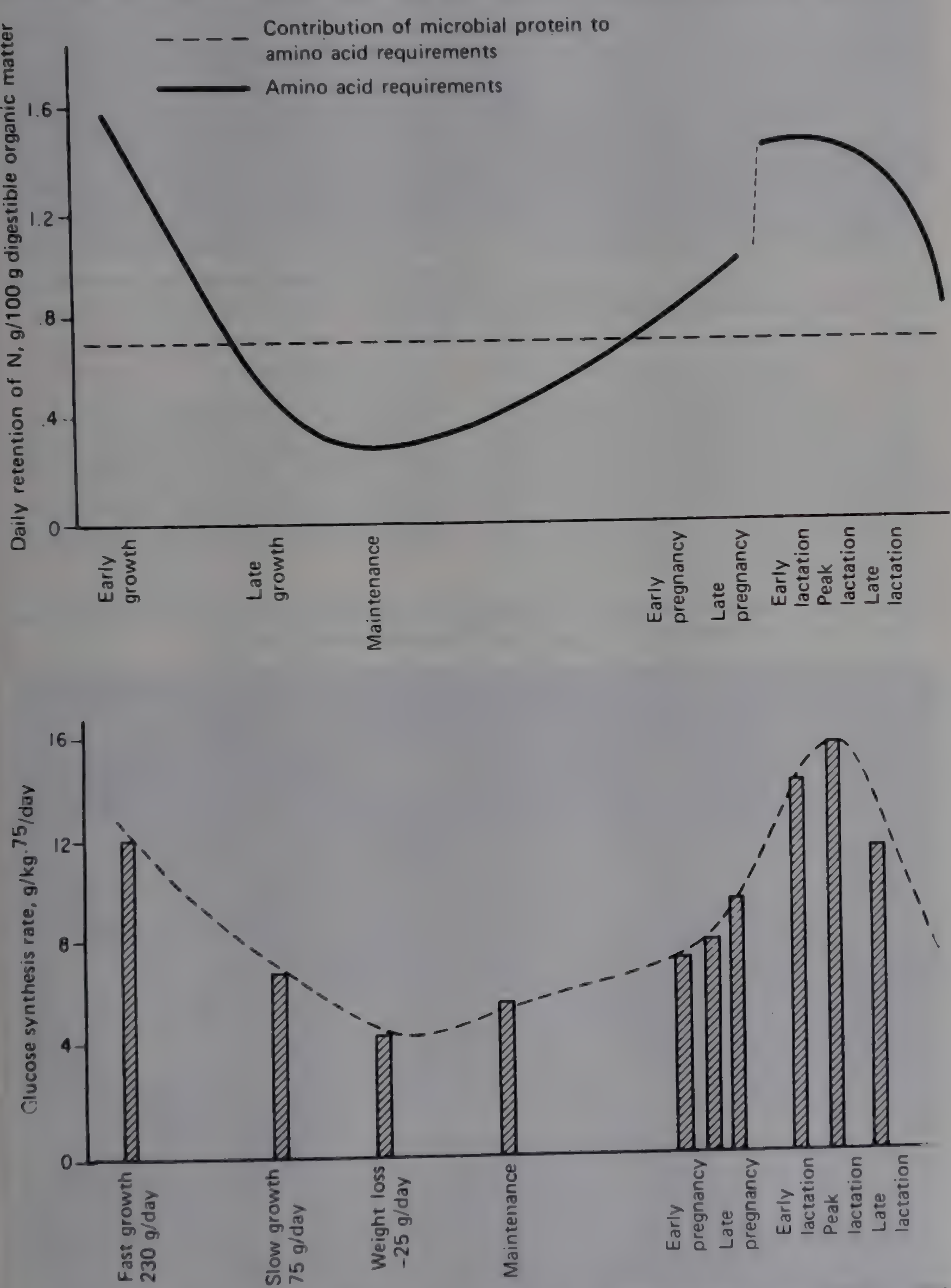
Glucose is another nutrient which may limit production rate and play a critical role when emphasis is on maximizing rumen function. The glucose needs of ruminants were once thought to be so small that they could be ignored. But it is now known that these requirements are sometimes very high, and that under certain feeding regimes (low protein/low starch diets) they are not easily met (Leng and Preston, 1976).

It appears that the pattern of glucose requirements is also related to productive rate and closely parallels the needs for amino acids (see graph).

The significance of the relationship between productive rate and requirements for amino acids and glucose lies in the high cost of both of these nutrients and/or their precursors relative to the basal energy and non-protein nitrogen components of the diet. Moreover, sources of amino acids (mainly as preformed protein) are generally to be found in feeds which are usable by humans. Known glucose sources (chiefly starch) fall into the same category.

This means that the degree to which ruminants are non-competitive with humans for feed supplies will vary inversely with their productive rate. While it is to be expected that increasing knowledge of rumen function on low protein/low starch diets will eventually allow these constraints to be lifted, the solution in the short term will be to avoid the critical peaks in the production cycle when supplement needs are highest. Ways of achieving this through manipulation of the production system are discussed later.

Pattern of requirements for amino acids and glucose in relation to phase of production [1]



[1] Amino acid requirements are expressed as N retained per unit digestible organic matter (Ørskov, 1970). Glucose requirements are expressed as the rate of synthesis of glucose per unit body weight (Leng, 1975).

Feed resources. If it is concluded that the ruminant is the preferred species for livestock development in the tropical world, then the feeds that are likely to be most appropriate will be those which are readily fermentable. They do not need to be rich in natural protein because of the ruminant's ability to utilize inorganic nitrogen.

These characteristics of "appropriate" feeds are of particular relevance in the tropics, because in these regions the crops which are highly productive and best adapted are those rich in fermentable carbohydrates, e.g. sugarcane, sweet potato, cassava and bananas.

Another important characteristic of feed crops for tropical regions is that they should be perennial. This is because the nature of the climate often makes annual cropping extremely hazardous in terms of seed bed preparation, sowing date and weed control. Annual crops are also much more prone to erosion. When these additional factors are taken into account, the virtues of sugarcane are particularly apparent, as it can be harvested from the same sowing for up to 10 years if necessary.

The final reckoning must be in terms of energy capture and utilization. The high energy cost of intensive temperate country agriculture has been highlighted by Blaxter (1974), with the final balance being negative, i.e. energy has to be introduced into the system to supplement that obtained by photosynthesis. An energy balance sheet has yet to be drawn up for a sugarcane feeding system. But what is clear is that this crop probably captures more solar energy per land area unit than any other; moreover, the possibilities for recovering fuel as biogas by fermentation of the undigested fractions will almost certainly result in the overall energy balance being positive.

So one answer to the question as to whether or not the tropics are appropriate for livestock production is that the potential of the sugarcane crop in the tropics far exceeds that of crops in temperate regions. The fact that this has been hitherto unrecognized reveals neglect of the concept of appropriate technology and how to

develop it. Perhaps if there had been less emphasis on the transfer of inappropriate temperate country technology and more attention had been paid to research to develop the real resources of the tropics, livestock production in these regions would not be in its present backward state.

Of course, it can be argued that all sugarcane is needed for sucrose production, and that this is a staple in the human diet. But, even leaving aside the nutritional significance (or otherwise) of sucrose in the human diet, direct competition will exist only where a sugar industry has already been established. However, even in such a situation, the mere by-products of sucrose extraction (molasses, cane tops, bagasse and filter mud) are enough to form the basis of a cattle industry. For example, Mauritius, which produces nearly one ton of sugar per inhabitant, plans to meet its milk and beef requirements from cattle fed sugarcane by-products (Preston, 1974).

The role of sugarcane *per se* as a cattle feed is in areas where there is no existing sugar industry. In the greater part of the humid tropics the possibilities for growing sugarcane are almost unlimited.

Management systems. It is commonly believed that there are only two ways of managing cattle: for milk production or for beef production. This belief is not only taught in animal husbandry textbooks, but it is generally claimed to be the most efficient way of supplying our needs for milk and beef. But it must be remembered that this philosophy of milk on the one hand and beef on the other reflects mainly experiences in the temperate regions of the world. It does not follow that today in the tropics (and perhaps even in temperate countries) such a separation and specialization is the most appropriate procedure.

One reason for re-examining this approach relates to the constraints on rate of production which arise if maximum reliance is put on rumen function, i.e. feeding cattle in a way that will not create competition with the human population.

A system of specialist milk production implies a lactation yield of 4 000 to 5 000 litres and the artificial rearing of the calf to permit maximum liquid milk sales. These are unlikely to be achieved under conditions where the diet is composed primarily of soluble carbohydrates and inorganic nitrogen. Thus specialist milk production is not an appropriate system for the tropics, unless the main items of feed are to be imported from the cereal-producing temperate countries. To accept that strategy, however, is to depart from the principal objective, namely the development of an appropriate technology based on the use of national resources. Superficially, this is the first indication that the tropics are not appropriate for efficient cattle production. Fortunately, however, this is only one side of the story. For beef is needed as well as milk, and the basis of a sound livestock strategy is to consider the two together.

Demand for beef and milk

The obvious starting point is the national requirement for beef and milk and the possibilities for export. Here it is necessary to differentiate between what might be consumed if purchasing power were not a limitation, and what is actually consumed by the population as a whole. For the purpose of this calculation, it is not necessary to estimate absolute figures, but rather the ratio between the two products. Also, as a general yardstick it is proposed to base this upon data from developed countries, on the assumption that this is what most developing countries aspire to when purchasing power is adequate. These theoretical demand figures are 50 kg carcass beef per year and half a litre (0.5 kg) of fresh milk equivalent daily.

The annual milk/beef demand ratio represented by these consumption rates is 3.6:1. A specialized dairy cow (e.g. Friesian) giving 4 500 kg per lactation produces a calf which eventually ends up as beef, either as a culled female or a fattened bull or steer. Assuming the weight of carcass produced in either of these categories is 250 kg, the milk/beef production ratio is 18:1. Since the demand ratio is only 3.6:1, this means that if milk production is based on a specialist system, either beef must be imported to make up the deficit, or there should be a parallel specialist beef production industry.

The general policy in the developed countries has been to opt for the latter alternative. In countries such as the United States, Brazil, Argentina and Australia, such a policy may be acceptable because there are large areas

Single-purpose Jersey cow and calf in Seychelles. Calf growth to weaning at 4 months was 800 g/day and lactation milk yield 1 700 kg.

Dual-purpose Creole cow and calf in Seychelles. Calf growth to weaning at 4 months was 1 kg/day and salable lactation milk yield was 1 600 kg.

of pasture land on which inexpensive ranching is feasible without recourse to supplementary feeding. In almost all other countries single-purpose beef production is a luxury operation which cannot be afforded.

The reasoning behind this argument is as follows: If the milk/beef demand ratio is 3.6:1 and the specialized dairy cow gives a production ratio of 18:1, then we need an additional four specialized beef cows for every dairy cow. But specialized beef cows, because of their low reproductive rate, are biologically and economically inefficient, particularly when there are no extensive grazing areas. Therefore, predicated on a philosophy of specialist milk and specialist beef, the greater the degree of self-sufficiency in both products, the less efficient the overall cattle industry becomes (since there are four inefficient beef cows for every efficient dairy cow), and the greater is the burden on the taxpayer in the end. As witness to this, the present government subsidy to the beef industry in the United Kingdom is almost $400 million. To achieve the desired milk/beef ratio without having to support an inefficient beef industry requires either the import of beef from countries which produce it more cheaply and which would be anxious to trade beef to pay for their own imports, or the restructuring of the cattle industry. For developing countries in the tropics with a rich agricultural potential, the latter course is more attractive.

Dual-purpose cattle. Such a restructuring involves the substitution of both specialized beef cattle and specialized dairy cattle by dual-purpose animals which produce milk and beef in accordance with demand. For a milk/beef demand ratio of 3.6:1, the specifications become a lactation yield of 1 500 kg in 300 days, and additional milk to suckle the calf throughout lactation to a weaning weight of 200 kg (at which point it can enter the fattening programme with minimal need for supplementary feeds).

In terms of milk alone, such a yield level may be viewed with derision by most cattle breeders as representing an unacceptable reversal of the technological clock. Nevertheless, there are a number of sound reasons why such a policy is particularly appropriate for the tropics, and for the developing countries in general:

1. A lactation yield of 1 500 kg is equivalent to an average of 5 kg/day during a 300-day lactation, plus an additional 2.5 kg/day on average for the calf (by restricted suckling). Such a yield level is compatible with the feed potential of the kind of crops that can be grown to best advantage in the tropics.
2. The milk obtained by the calf by suckling constitutes an excellent source of both amino acids and glucose precursors. High growth rates can therefore be achieved by supplementing it with the same basal ration (carbohydrates and inorganic nitrogen) fed to the cows.
3. Combined milking and restricted suckling have been shown to reduce diseases such as mastitis to negligible proportions (Preston and Ugarte, 1972).
4. Mean yields of 5 kg/day can be achieved by daily milking: milking could even be avoided on Sundays and holidays, leaving the calves to consume all the milk on these occasions.
5. A dual-purpose animal of intermediate milk-producing potential is easily produced by crossbreeding almost any type of indigenous (and therefore adapted) cow with recognized dairy or dual-purpose bulls.
6. Crossbreeding — through the manifestation of heterosis — leads to better adaptability, improved fertility, reduced mortality and more efficient growth and feed conversion.
7. In such a scheme there is no need to pursue a genetic improvement programme for milk (this avoids the use of expensive proven sires or semen), and improved beef traits can be incorporated easily by selecting bulls produced in the herd, on the basis of performance from weaning to slaughter.

Multi-purpose cattle. Cattle, in addition to producing milk and beef, can also help to alleviate the effects of the oil crisis.

When a forage crop such as sugarcane is consumed by cattle, some 40 percent in terms of dry weight is excreted as faeces and urine. This

effluent contains undigested carbohydrate, the three mineral elements which make up standard fertilizers (nitrogen, phosphate and potash) and valuable trace elements.

If all of this effluent is collected and passed through a simple anaerobic fermenter, it is possible to produce biogas rich in methane that can be used as a source of fuel and, after suitable processing, of light and power. This process utilizes only part of the carbon, hydrogen and oxygen present in the effluent and leaves intact the mineral elements which can be recovered after the fermentation process and used for fertilizer.

Table 1 shows the fuel and fertilizer value of a 120-ton/ha crop of sugarcane after processing through cattle. At a power cost of $0.08/kwh, the fuel value is the equivalent of $1 835 (enough to supply the needs of three households), while the fertilizer recovery is equal to $544.

The economics of establishing and operating a multi-purpose cattle enterprise in the tropics using sugarcane as the basal feed resource are set out in Tables 2 and 3.

In a multi-purpose cattle unit, each breeding cow gives 5 kg milk per day for a 300-day lactation and also rears her calf to a weaning weight of 210 kg. After weaning, the calf is fattened intensively at a growth rate of 0.85 kg daily to reach a slaughter weight of 400 kg at approximately 17 months of age. On a yearly basis we then have 365 mature cow days, 300 calf days and 210 fattening days.

The technical coefficients assumed to apply to this population are a 90 percent calving rate and an 80 percent

Table 1. **Fuel and fertilizer value of a 120-ton/ha sugarcane crop** [1]

Output	Amount produced	Energy produced	Value
Fuel	*m^3*	*kwh*	*U.S.$*
Biogas	[2] 3 276	[3] 2 290	[4] 1 835
Fertilizer			*U.S.$*
Nitrogen	979 kg at $0.40/kg		392
Phosphate	145 kg at $0.52/kg		76
Potash	189 kg at $0.40/kg		76
Total			544

[1] One cow unit (cow and weaner) eats 5.84 tons dry matter per year and excretes 2.34 tons of dry matter. A 120-ton/ha sugarcane crop feeds 7.06 cow units which excrete 16.5 tons of dry matter. — [2] Biogas derived from manure containing 50 to 60% CH_4. — [3] At 7 kwh/m^3. — [4] At power cost of $0.08/kwh.

Table 2. **Technical coefficients for a multi-purpose cow unit (Holstein-zebu crosses) fed sugarcane**

Assumed calving rate	0.9				
Assumed weaning rate	0.80				
Salable milk	5 kg/day for 300 days				
Calf growth to weaning	600 g/day				
Weaning weight	200 kg				
Growth from weaning to slaughter	850 g/day				
Age at slaughter (400 kg)	17 months				
Intakes and feed costs		Sugarcane	Urea	Protein supplement	Minerals
Milking/breeding	*kg/day*	30	0.30	1.0	0.06
Calves to weaning	*kg/day*	8	0.08	0.3	0.03
Fattening	*kg/day*	20	0.20	0.6	0.06
Total	*tons/year*	17	0.175	0.581	0.044
Assumed cost	*U.S.$/ton*		150.00	250.00	100.00
Assumed total cost	*U.S.$*		26.29	145.00	4.40

SOURCE: Centro Dominicano de Investigación Pecuaria con Caña de Azúcar, Dominican Republic.

weaning rate. The cost of establishing one hectare of sugarcane is estimated at $1 500 and it is assumed to have a productive life of five years. The price of a balanced 30 percent protein supplement is $250 per ton, urea is $150/ton and minerals $100/ton. Milk sells ex-farm at $0.20 litre and beef at $0.80/kg live weight. The value of the fertilizer elements in the effluent is estimated at $0.40/kg nitrogen, $0.52/kg phosphate and $0.40/kg potash. A unit of one breeding cow plus followers will produce 2.5 tons of dry matter as effluent per year, and from this is recovered 468 m³ of a mixture of methane/carbon dioxide with an overall fuel value equivalent to 3 270 kwh, valued at $0.08/kwh. All of the effluent is returned to the sugarcane (but in fact not all is required, and part could be used as fertilizer for vegetable crops).

Table 3. **Costs and returns for multi-purpose cow units** [1]

		U.S.$	Percent
Output			
Milk	1 350 litres at $0.20/litre	270	31
Beef	320 kg at $0.80/kg	256	30
Biogas	3 270 kwh at $0.08/kwh	262	30
Fertilizer	139 kg N 21 kg P 27 kg K	77	9
Total		865	
Investment			
Land	0.14 ha[2] at $240.00/ha	34	
Cow	450 kg at $ 0.80/kg	360	
Feedlot	$200/head	200	
Feed supplement (3 months)		58	
Establishing sugarcane at $1 500/ha		210	
Total		862	
Inputs			
Cane establishment depreciation [3]		43	
Fertilizer (effluent)		77	
Supplements		176	
Interest at 12%		103	
Feedlot depreciation		20	
Total		419	
Return to labour and management			
Per cow unit		446	
Per hectare		3 289	

NOTE: In the calculation on return to labour and management, the investments and inputs necessary for the production of biogas are not included.
[1] Each unit includes 365 cow days, 300 calf days and 210 fattening days. — [2] Assumes 120 tons cane/ha/yr. — [3] Lasts 5 years.

The final economic analysis highlights the potential contribution to output made by all four products from the cattle enterprise. Obviously, the degree to which these potential outputs are converted into cash income and/or personal benefits (particularly the fuel from effluent) will depend on the development of appropriate technology, supply of credit and marketing services.

But the intensity of production in terms of the limited land area needed to support one family, the almost certainly favourable overall energy balance and the minimum dependence on imports are all factors that make the concept relevant to the sociological and nutritional problems facing many developing countries.

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Saving grain in
by feeding dried

by E. Cordiez, O. Lambot, J.M. Bienfai

Among the factors contributing to improvements in the techniques of beef production, feed is undoubtedly the most important, as it represents three quarters or more of the total cost of animal production. To obtain high levels of productivity through superior feed conversion efficiency, it is essential to provide an adequate, well-balanced diet; otherwise a large part of the feed consumed will be devoted to meeting maintenance needs only.

Of the various types of feeds that may be provided, energy feeds are most important, irrespective of whether they are utilized for beef production (with steers slaughtered at 15 to 18 months of age at live weights ranging from 470 to 530 kg) or for milk production. While feed constitutes the principal component of the total cost of animal production, the cost of energy feeds exceeds that of all other nutrients. The energy content of the diet, i.e. the amount of energy supplied per unit of weight, may therefore be regarded as a prerequisite to success in animal production. The accurate assessment of the energy content of feeds and a thorough knowledge of the factors influencing their use are thus essential to ensure efficient utilization.

The authors are at the University of Liege, Faculty of Veterinary Medicine, Rue des Vétérinaires 45, B1070 Brussels, Belgium.

It has long been known that in fattening steers for beef production, indiscriminate substitution of one farm feed for another solely on the basis of their theoretical energy values produces undesirable results, particularly in regard to the quality of animal products. This means that in order to attain the highest efficiency, certain feeds should preferably be reserved for certain classes of animals; thus, feeds that are good for three-year-old steers are not necessarily the best for younger animals. A similar idea was expressed by P. Rintelen, Director of the Agricultural Institute of Weihenstephan: "The usual methods of assessment (based on starch units or feed units) are not always appropriate for determining the feeding value of forages or fodder crops used for fattening cattle. Moreover, while natural or cultivated grasslands provide a poor basic feed for intensive fattening, they serve as an excellent feed resource for dairy herds."

Energy value of feeds

It is a well-established fact that the conventional method of expressing the energy value of feeds in terms of starch units or fodder units has little merit when one is dealing with high production levels. Nevertheless, the assignment of a true energy value (expressed as net energy) to a feed or diet would be a most useful contribution to progress in animal production. A certain differentiation of net energy values has been achieved for the different animal species, but within species individual animals exhibit considerable variation depending on whether they are in the maintenance or production phase.

Blaxter and his co-workers have shown that the conversion of digested energy into net energy of production is not the same for the two major categories of feed (coarse and concentrated feeds), nor is it the same for maintenance and production requirements. In order to cover maintenance requirements, the efficiency of conversion of digestible energy into net energy of production is practically the same for both coarse and concentrate feeds; but insofar as production requirements (lactation, gestation, fattening, etc.) are concerned, the conversion of concentrates is more efficient. This has been confirmed by the work of Lofgreen and Garrett (1968) on the energy requirements for maintenance, growth and fattening of beef cattle. They showed that the net energy value of a feed varies with the use to which it is put, the net energy value for maintenance being vastly different from that for production (Table 1).

It should be noted that some feeds, e.g. hay, may suffice to cover maintenance requirements, but their value is greatly reduced if they are used to meet production needs. On the other hand, high-energy feeds such as grains in general, oil cake and dried sugar

[b]eef production
[s]ugar beet pulp

[P]ondant and C. Van Eenaeme

beet pulp have an efficiency for production purposes that is 60 to 100 percent of their energy value for maintenance.

Table 1 shows that dried sugar beet pulp has a net energy value practically identical to that of barley, whether fed for production or for maintenance purposes. Cordiez *et al.* (1963) arrived at the same conclusion on the basis of trials conducted with young beef steers fed a diet containing up to 70 percent dried beet pulp. In more recent experiments where beet pulp was used to supplement diets based on maize silage, the equivalence of the feed value of pulp and barley was fully confirmed.

Research programme

Our research was carried out both at the farm and at the experiment station with the support of grants from the Agricultural Research Department of the Ministry of Agriculture, and from the Institute for the Promotion of Scientific Research in Industry and Agriculture. Since we were principally concerned with obtaining practical results that would have general application, the objective of these studies was to determine the relative roles of farm-produced and commercial feeds as components of the diets of young bulls during the growing-fattening phases at a weight range of 250 to 350 kg initial weight and 475 to 525 kg slaughter weight. The trials at the experiment station involved the study of volatile fatty acids and ammonia in the rumen fluid.

Our work was therefore not concerned with the production of "baby beef," which involves the feeding of animals from a very young age to a slaughter weight of about 450 kg on high-energy rations containing a large proportion of grains, resulting in the production of the so-called "barley beef." Our experiments were concerned with trying to reduce as much as possible the use of grains in beef production.

Diets based on dried beet pulp. For these trials over 300 bulls on six farms were used in two years. The animals were divided into homogeneous groups of 8 to 10 head each and were fed on experimental rations from the age of 8 to 10 months. In order to facilitate between-diet comparisons, the results of all trials are expressed here in relation to the weight range that was common to all of them, i.e. 280 to 519 kg.

Dried beet pulp, the basic ingredient of the ration, was fed *ad libitum* in order to allow maximum consumption. Supplementary compound feeds were provided at three levels (0.65, 0.75 and 1 percent) in fixed proportion to the live weight of the animals; these correspond to the intake levels shown in Table 2. The protein supplied was consistent with generally accepted norms; the crude protein content of the supplement diminished as fattening progressed so that the total amount of protein consumed was kept at a fairly constant level.

The dried beet pulp was usually provided to the animals once every 24 hours or placed in feed troughs within their reach. The incidence of bloat was less than two per thousand because the animals were able to consume 0.5 to 1.0 kg straw per day from the bedding provided and had access to all the water they wanted; they were also allowed a period of three to four weeks to adjust to the dried beet pulp, which was gradually increased during this period.

As shown in Table 2, the average daily gains were fairly similar for all three treatments and were only slightly influenced by the proportion of beet pulp and grain in the rations. When the level of supplementation declined from 1 to 0.65 percent of live weight, the animals compensated for the decrease in grain consumption by an almost proportionate increase in the intake of dried pulp. From these observations it would appear that the total consumption of dry feed per kg live weight gain was virtually the same for all three diets (6.8 to 6.94 kg). They demonstrate the equivalence in energy value of all three diets and show that dried beet pulp has a nutrient value very close to that of grain.

Assuming that the gain in carcass weight represents 63 percent of the increase in live weight, the quantities

of dried beet pulp and grains consumed per kg of carcass weight produced may be estimated to be as follows:

(*a*) at the 1 percent level of supplementation: 6.0 kg dried beet pulp and 2.97 kg grains;
(*b*) at the 0.75 percent level: 6.92 kg dried beet pulp and 1.78 kg grains;
(*c*) at the 0.65 percent level: 7.75 kg dried beet pulp and 1.16 kg grains.

Reducing the supplementation of compound feeds from 1 to 0.65 percent resulted in a saving of grain of 1.81 kg per kg of carcass weight. In the nine EEC countries, the area devoted to sugar beet cultivation is about 1 500 000 ha; with an average crop of 42 tons of sugar beet per ha and 52 kg of dried beet pulp per ton of beet, the potential production of dried pulp is about 3 276 000 tons. If all this pulp were used for beef production, 423 000 tons of carcass weight would be produced at the 0.65 percent level of supplementation, with a saving of 765 000 tons of grain as compared with the 1 percent level.

Rolled barley versus dried beet pulp

As dietary staples. In a 190-day trial conducted at the experiment station using young steers for fattening, the diet consisted of rolled barley or dried beet pulp fed *ad libitum* as the staple feed and a 33 percent crude protein supplement to cover standard protein, mineral and vitamin requirements. Between the two staples, practically no difference was observed in average daily weight gain (1.29 kg and 1.31 kg respectively) and in feed intake per kg increase in live weight (5.8 kg rolled barley and 5.6 kg dried beet pulp).

In a trial conducted on the farm, one diet consisted of 81.7 percent rolled barley and 18.3 percent protein supplement while a second consisted of 65 percent dried beet pulp, 16.2 percent rolled barley and 18.8 percent protein supplement. The protein supplement contained 74 percent oil cake (soybean and groundnut), 7 percent alfalfa meal, 10 percent molasses, 3 percent dicalcium phosphate, 2 percent limestone and 4 percent of a vitamin-enriched mineral supplement. The average daily gains of the young bulls fed these diets at weights ranging from 250 to 500 kg were similar, i.e. 1.27 kg for the first diet and 1.24 kg for the second. Feed intakes per kg of carcass weight were 8.40 kg barley and 1.88 kg compound feed for the

Table 1. **Net energy value of selected feeds**

Feeds	For maintenance (NE_m)		For production (NE_g)		NE_g as % of NE_m
	kcal/kg	In % of barley	kcal/kg	In % of barley	
Dry roughages (90% dry matter)					
Alfalfa hay					
21% fibre	1 230	64	700	55	56.9
29% fibre	1 010	52	300	24	29.7
Timothy hay					
before bloom	1 230	64	700	55	56.9
late bloom	1 030	53	380	30	36.9
Barley straw	910	47	140	11	15.4
Wheat straw	910	47	140	11	15.4
Concentrates (90% dry matter)					
Barley grain	1 930	100	1 270	100	65.8
Maize grain	2 030	105	1 320	104	65.0
Beet pulp, molasses, dried	1 830	95	1 210	95	66.1
Soybean oil meal					
Expeller	1 850	95	1 230	97	66.5
Solvent	1 720	89	1 150	91	66.8

SOURCE: Lofgreen and Garrett, 1968.

Table 2. **Results obtained with diets based on dried beet pulp for young bulls** [1]

	Supplementation level as percentage of live weight		
	0.65	0.75	1.00
Supplement provided		*kg/day*	
up to 300 kg (live weight)	1.6	1.9	2.5
from 300 to 400 kg	2.3	2.6	3.5
from 400 kg to slaughter weight	2.9	3.4	4.5
Average daily gain	1.24	1.21	1.26
Intake/day		*kg*	
Dried beet pulp	6.05	5.27	4.76
Grain	0.90	1.36	2.36
Protein supplement	1.60	1.60	1.60
Intake/growth		*kg*	
Dried beet pulp	4.88	4.36	3.78
Grain	0.73	1.12	1.87
Protein supplement	1.29	1.32	1.27

[1] Initial weight, 280 kg; final weight, 519 kg.

diet based on barley, and 6.68 kg beet pulp, 1.67 kg barley and 1.93 kg compound feed for that based on beet pulp. Thus, barley consumption per kg of carcass weight was 6.73 kg less for the diet based on sugar beet pulp than on the barley-based diet, and by supplementing the beet pulp with compound feed equivalent to 0.65 percent of the live weight of the animals, the saving on barley would have amounted to 7.24 kg per kg carcass weight. If all the beet pulp that could be produced in the nine EEC countries were used at the 0.65 percent level, this would lead to a consumption of 1 256 000 tons of barley to produce 423 000 tons carcass weight. On the other hand, with a diet based on barley for the production of "barley beef," the same carcass yield would require 3 062 000 tons of barley, i.e. an additional consumption of 1 806 000 tons.

Table 3. **Results obtained from feeding barley and dried beet pulp to young bulls as a supplement to maize silage**

		Supplement	
		Rolled barley	Dried beet pulp
Number of animals		114	115
Initial weight	*kg*	305	300
Final weight	*kg*	502	508
Average daily gain	*kg*	1.19	1.20
Intake/day		*kg*	
Maize silage		13.9	13.9
Rolled barley		1.75	—
Dried beet pulp		—	1.75
Protein supplement		1.50	1.50

As supplements. Trials conducted at the experiment station showed that digestibility of organic matter remained practically the same (at close to 67 percent) when dried beet pulp replaced rolled barley in a ration based on a mixture of maize (i.e. the aerial part of the plant dehydrated in the dough stage, ground and pelleted) and barley; the ration also contained a 35 percent crude protein supplement.

Another trial conducted on the farm compared the effects of using dried beet pulp and rolled barley, respectively, as supplements to maize silage containing 30 percent dry matter. The rations were fed at levels up to 0.75 percent of the live weight of the animals. They included a compound feed containing 38 percent crude protein that was fed at the rate of 1.5 kg per animal per day. The compound feed consisted of 81 percent oil cake (groundnut, cottonseed and soybean meal in equal parts), 9.5 percent molasses and 9.5 percent of a premix providing the required supplementary minerals, trace elements and vitamins. Table 3 presents the results obtained from two groups of over 110 animals each that had identical daily feed intakes when offered rations based on rolled barley and dried sugar beet pulp respectively. They show that the kind of energy supplement used exerted no influence on the average live weight gain. Intakes of feed per kg increase in live weight gain in the two groups were identical: 11.6 kg maize silage, 1.25 kg protein supplement and 1.45 kg of either dried beet pulp or rolled barley. The saving per kg of carcass produced, with dressing percentages of about 60 percent, amounted to 3 kg when beet pulp was used as the sup-

Young bull raised for meat production on dried sugar beet pulp

plement instead of barley, i.e. 364 kg per animal.

Discussion

Our experiments have demonstrated that in diets fed to young steers for fattening, the feeding value of dried beet pulp is identical to that of rolled barley, irrespective of whether it is used as a staple food or as a supplement. These observations confirm the findings of Lofgreen and Garrett (1968) and are in agreement with the net energy values of these feeds (Table 1).

Bhattacharya and Sleiman (1971), working with wether lambs, determined the nutrient digestibility and energy utilization of rations containing 60 percent of a staple food and 40 percent of a mixture of wheat bran, groundnut oil cake, alfalfa hay, salt, limestone and bone meal; the staple food consisted of maize meal and dried beet pulp in proportions that varied inversely from 0 to 100 percent; thus, the four experimental rations contained 0, 30, 45 and 60 percent beet pulp. With average digestibility coefficients of 76.7 percent for dry matter and 76.9 percent for energy, there were no significant differences due to rations.

Beet pulp may therefore be considered as an energy source having the same value as maize grain, even when it comprises 60 percent of the ration. The digestibility of the crude fibre increases with the pulp content of the ration. This was attributed to the high digestibility of the sugar beet pulp fibre due to its low lignification. However, with diets of high grain content Kesler and Spahr (1964) considered that the lower digestibility of fibre was due to the disappearance of bacteria and protozoa that live on cellulose in the rumen, while McCullough and Smart (1970), studying the digestibility of cellulose *in vitro*, observed a faster and greater disappearance of cellulose when the ferment utilized consisted of rumen fluid taken from bulls on a diet with a high beet pulp rather than maize grain content.

In a lactation trial with eight Holstein-Friesian dairy cows, Bhattacharya and Sleiman (1971) compared a control ration containing 57 percent barley with an experimental ration containing 55 percent beet pulp; no significant difference was observed in either changes in live weight or fat-corrected milk production. In a series of three experiments, Bhattacharya and Lubbadah (1971) studied the ef-

fect of replacing maize with dried sugar beet pulp in high-concentrate dairy cow rations. The control diet contained 73 percent maize, while in the experimental rations 50, 75 and 100 percent respectively of the maize was replaced by beet pulp. No significant differences were observed among rations in live weight gain, milk yield and composition, digestibility of dry matter and energy. Castle (1972) made similar observations during experiments lasting up to 18 weeks with diets in which the concentrate ration contained 80 percent dried beet pulp instead of barley; he concluded that an energy value equivalent to that of barley can be attributed to beet pulp. This was confirmed by the findings of energy balance sheets drawn up by van Es *et al.* (1971).

Kosar *et al.* (1974) used dried beet pulp (to which molasses had been added) to replace 75 percent of the concentrate in rations based on maize silage for dairy cows and found no significant differences in milk production.

In a recent experiment, Bhattacharya *et al.* (1975) studied the replacement of maize by dried beet pulp in high-energy rations fed to sheep and young bulls during the growing-finishing period. The rations contained 90 percent maize grain or 90 percent dried beet pulp, or a mixture of the two in equal proportions (45 percent each); the rest of the ration consisted of 5 percent molasses, 1 percent urea and 4 percent of a mineral mixture fortified with vitamins. These diets were fed to sheep weighing from 34.5 to 55 kg. When the diet contained beet pulp there was a higher average daily weight gain, a better feed conversion efficiency and improved carcass quality. The same was true for dry matter digestibility as measured in young bulls: the digestibilities were 78.1 percent for the pulp plus maize ration as compared to 76.0 percent for the ration containing 90 percent maize. Our own results have confirmed these findings; the dry matter digestibility in our trials with young bulls was 77.9 percent on a diet consisting of 62 percent dried beet pulp, 14 percent flaked maize, 5 percent hay (to ensure proper functioning of the rumen) and 19 percent of a supplement that had a 35 percent crude protein content and provided the necessary minerals and vitamins.

Conclusions

All the results reported here show that beet pulp is an excellent source of energy for ruminants during the growing-finishing period and during lactation. In compounding high-energy rations, beet pulp may be used as the sole source of energy or as a replacement for some of the grain, whether it be barley or maize. Levels of beet pulp as high as 90 percent of the ration have no detrimental effects on animal performance.

In feeding for beef production, dried sugar beet pulp may therefore be used as an energy source to replace a substantial part of the grain component of the ration. In practice, the ration will be fed at a level equivalent to 0.65 percent of the live weight of the animal. The quantities of supplements that should be fed to animals of different weights and the average intake of dried pulp fed *ad libitum* are shown in Table 2.

The capacity of young bovines to utilize dried beet pulp with remarkable efficiency makes it possible to conserve a considerable portion of the grain crop for direct use by humans and thus helps to reduce the competition between man and animals in meeting energy requirements.

Sectional view of ninth rib of a young bull raised on a beet pulp-based ration

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an indigenous in tropica

by E. González-Jiménez

The capybara (*Hydrochoerus hydrochaeris*) is a South American rodent of great interest as an indigenous resource for meat and hide production in the flood plain ecosystems of the American tropics. It has been studied for more than 400 years by many authors, mostly naturalists who have travelled far and wide over South America. In recent times its high biological potential and its ability to adapt to high ambient temperatures and humidities have generated greater interest and found expression, for example, in the work of Ojasti (1973) and in seminars such as the Primer Seminario Colombo-Venezolano sobre Chigüiros y Babillas held at Bogotá in 1974. The aim of the Bogotá seminar was to promote joint research between Venezuela and Colombia in the utilization of this animal resource which abounds in the vast llanos extending from the Orinoco river to the Colombian Andes.

The capybara has long been the object of intense exploitation. It occurs in large numbers over extensive areas of South America, but there are no precise data on numbers. Mones (1973) has drafted a map showing the present distribution of the species.

Only a few species of American wildlife have been domesticated. They are: the llama, the alpaca and the guinea-pig used by the Incas; the turkey of the Aztecs; and more recently, the deer tamed by the Chibcha tribes and the capybara domesticated by the Piaroas. The domestication of the capybara has been facilitated by both its temperament and its utility, and has now reached an advanced stage.

E. González-Jiménez *is Professor of Animal Nutrition at the Institute of Animal Production, Faculty of Agronomy, Central University of Venezuela. Maracay, Venezuela*

Systematics and common names

The capybara is a member of the order *Rodentia*, family Hydrochoeridae, genus *Hydrochoerus* (Bunnich), species *hydrochaeris* (Linnaeus), with the synonym *H. capybara* (Erxl.), which includes several subspecies. According to Mones (1973), many of these may prove to be synonyms when the variability of the species has been studied. Some of the subspecies known at present are: *H. hydrochaeris isthmius* of the Panamanian isthmus, western Colombia and the shores of Lake Maracaibo; *H. hydrochaeris uruguayensis* of southern Uruguay; and *H. hydrochaeris notialis* of Paraguay, northeastern Argentina and southern Brazil (Mello, 1947).

The common names for this rodent in

Capybaras in the llanos

ybara

ource of meat
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ne various countries, regions and dialects
re as follows:

rgentina, Uruguay, Paraguay and southern
razil: *carpincho* or *capincho*; *capiguara* is
lso common.

razil: *capibara* or *capivara.*

eru: *ronsoco, capibara, samanai.*

olombia (by regions): Amazon: *capibara*;
ucumo: *dia-baj*; Caqueta-Guayabero: *capi-*
ara, julo; Ariari Sur: *capibara, jesus*;
Arauca-Casanare: *chigüiro, tanacoa, pataseca, bocaburro* and *culopando*; Magdalena river: *ponche, cabiari*; Cauca river: *sancho.*

Venezuela (Indian names): Cumanagotos and Palenques: *chigüire*; Caribs: *capigua*; Tamanacos: *cappiba*; Maipures: *kiato*; Yaruros: *chindo*; Guahibos: *chindoco.*

Panama: *poncho.*

In the English-speaking world the animal is known by the Guaraní term capybara; in German it is known as *Wasserschwein*; in Dutch as *water zwyn* (in Surinam); in French Guiana as *cabiai*; and in other French-speaking countries as *cochon d'eau.*

pure state, Venezuela

Description

The capybara is the largest living rodent. It is generally as large as a pig and resembles it even in its brownish yellow coat colour. It is more than 100 cm long and 50 cm high and exceeds 50 kg live weight; weights of up to 75.8 kg have been reported (Donaldson *et al.*, 1975). The body is wide and massive; the neck short; the head long, high and wide; the snout blunt; and the upper lip cleft. The ears are small, hairless and mobile. The rear paws are longer than the front and the toes are partly webbed. There is no tail, but there is a fold covering the anus. The female has twelve teats arrayed in six symmetrical pairs.

The capybara moves nimbly on solid ground; when pursued it can cover 100 to 200 metres, with pauses, but tires easily and lapses into hyperthermia. When this happens, the hunter can easily catch it and kill it with a club. However, the capybara usually seeks bodies of water (lagoons, water channels and swamps), swims well and can therefore elude its pursuers.

The animal is nocturnal and, like most herbivores, grazes during the early hours of the morning and in the evening. It feeds mainly on grasses, browses rarely, and sometimes eats aquatic plants such as the water hyacinth (*Eichhornia* species) and some bottom-dwelling lake algae (Osgood, 1912).

Digestion and nutrition

The digestive system of the capybara is specially suited to the utilization of forages. Its dentition includes one pair of pre-molars and three pairs of mo-

lars with the back molars covering an area as large as the other two molars and the pre-molars combined. This provides a very efficient grinding mechanism. The strong mandibles also facilitate grinding of the feed, and their articulation makes it possible for the mandibles to move in a front-to-rear direction, as described by Escobar and González Jiménez (1973). The incisors are capable of harvesting forages such as *Paratheria prostata*, which are short and nutritious and can be harvested only by lipped animals (e.g. the horse) and not by cattle. As a result, the capybara does not compete with cattle for grazing when the dry season commences; this was demonstrated by Escobar and González Jiménez (1973), who compared the cuticular remnants in the faeces of the two species at different times of the year. Using the method of Cavender and Hansen (1970), we have determined the flora grazed by the capybara in the flood plain savanna region of southern Venezuela. Table 1 shows the proportions of the different flora consumed in the diet.

The digestive system of the capybara includes a reservoir for feed fermentation, the caecum, that has a relative capacity greater than that of the rumen-reticulum; the caecum represents the key to its digestive physiology (Table 2). Our results show that the digestive abilities of the capybara and the sheep are similar when only forage is fed, and that the capybara shows a marked tendency to superiority when the proportion of concentrate increases in a mixed ration (Table 3). The latter observation might be explained by the higher efficiency of the enzymatic digestion-fermentation strategy of non-ruminant herbivores over the fermentation-enzymatic digestion strategy of ruminants in diets of decreasing fibre concentration. This may be due to the greater efficiency of the flora and fauna in the caecum of the capybara, where protozoans abound (McClure, 1970). The animal's caecal fluid also has a better *in vitro* digestive capacity than the ruminal fluid of sheep (González Jiménez and Escobar, 1975). This accounts for the fact that among non-ruminant herbivores, the capybara is best able to digest forages.

Reproductive efficiency

The capybara produces 1.2 to 1.8 litters per year, with four to six progeny per litter under natural conditions (Ojasti, 1970). However, more than eight progeny per litter have been obtained in zoological gardens, largely as a result of better feeding. Birth weights vary between 1.2 and 2 kg, depending on sex and size of litter. Sexual maturity is reached in both sexes at one to two years of age, at live weights ranging from 30 to 40 kg.

Distribution of the family Hydrochoeridae

Table 1. **Proportions of plant species of the flood plain savanna in the total dry weight ingested by the capybara**

Plant species	During flood	At flood recession	At end of dry season
Hymenachne amplexicaulis	43	25	20
Paratheria prostata	0	17	16
Leersia hexandra	35	15	8
Sporobolus indicus	3	9	17
Panicum dichotomiflorum	1	5	1
Axonopus sp.	0	4	14
Luziola sp.	0	2	1
Panicum laxum	12	1	10
Panicum junceum	1	1	1
Setaria geniculata	1	1	1
Oryza perennis	1	1	0
Panicum zizanioides	1	1	1
Eragrostis acutiflora	1	1	1
Paspalum chaffanjonii	4	1	1
Paspalum orbiculatum	1	1	1
Cyperaceae	3	16	8
Eichhornia sp.	1	2	1
Others, including unidentified species	3	3	7

Table 2. **Digestive capacity of capybaras, cattle and sheep**

	Capybara		Cow	Sheep
	g	. . . .	*Percent*	. . . .
Rumen	—	—	53	53
Reticulum	—	—	2	5
Omasum	—	—	5	2
Abomasum or stomach	113 ± 58	10	6	7
Small intestine	38 ± 16	3	20	20
Caecum	869 ± 274	74	2	2
Large intestine	154 ± 91	13	12	10

SOURCE: Parra and González Jiménez, 1971.

Adult animals weigh between 40 and 60 kg.

Table 4 compares the reproductive efficiency of the capybara with that of cattle in the llanos of Apure state, Venezuela, using the parameters established by Estrada (1966). Our estimate of the length of the gestation period is 147 days. This confirms figures quoted by Zara (1973) on the basis of carefully conducted studies at the zoological gardens at Evansville, Indiana, in the United States. In view of the difficulty of measuring gestation lengths under non-experimental conditions, it had previously been assumed that they were probably 3 months, 3 weeks and 3 days, as for pigs.

The capybara is six times as efficient as cattle in its reproductive performance under the conditions prevailing in the flood plain savanna. This permits offtake rates of about 40 percent, without detriment to the production potential of the herd. By contrast, the corresponding offtake rates for cattle in the llanos are no more than 9 to 11 percent.

Meat production efficiency

In its natural state, the capybara achieves a growth rate of about 54 g per day (Ojasti, 1970). However, under captivity and with better feeding, a higher growth potential exceeding that of tropical sheep breeds has been demonstrated. Comparison of the production efficiency of capybaras and cattle has shown that capybaras are 3.5 times as efficient as cattle (Table 5). Furthermore, assuming a stocking rate of 0.80 capybaras per ha (which currently obtains on some ranches in the flood plain) and 0.26 cows per ha, the corresponding production figures obtained are 63 kg/ha/year for the former and 14 kg/ha/year for the latter. Escobar (1973) has shown that on a ranch raising both species of animals, the net cash return per hectare was three times higher from the capybara than from cattle (i.e. about U.S.$11.00 vs. $4.00). The productivity figures were similar to those obtained in Table 5.

Utilization

The capybara is very easy to capture. In Venezuela the hunting season lasts from December to Easter. The meat is salted for consumption. Catholics are allowed to eat capybara meat during this period, and this has led to the tra-

Table 3. **Comparison of the capybara, rabbit and sheep in terms of the digestibility of the dry matter in feed containing different proportions of forages and concentrate feeds**

	Diet A	Diet B	Diet C	Diet D	Diet E
Composition of feed on dry matter basis			*Percent*		
Concentrate	0	25	50	75	100
Forage	100	75	50	25	0
Digestibility of dry matter			*Percent*		
Capybara	50.5	59.0	65.6	76.0	84.7
Rabbit	39.5	49.4	95.5	61.1	79.8
Sheep	49.1	54.5	59.8	65.2	70.5

The digestibility values were calculated using the following equations:

Capybara $y = 50.56 + 0.342x$ r: 0.86**, Sy.x = 6.17, N-11

Rabbit $y = 39.53 + 0.394x$ r: 0.99**, Sy.x = 1.93, N-10

Sheep $y = 49.15 + 0.214x$ r: 0.92**, Sy.x = 2.99, N-10

SOURCE: González Jiménez and Escobar, 1975.
NOTE: ** significant at 1 percent level.

Table 4. **Reproductive efficiency of capybaras and cattle under natural conditions**

		Capybaras	Cattle
a) Length of gestation	*days*	147	275
b) Progeny per litter		4.73	1.0
c) Litters per year		1.83	0.5
d) Weight of dam	*kg*	45	350
e) Average weight of progeny	*kg*	1.3	28
Reproductive efficiency [1]		0.25	0.04

[1] Weight of progeny per kg live weight of dam per year $\frac{b \times c \times e}{d}$

Table 5. **Meat production efficiency of capybaras and cattle**

		Capybaras	Cattle
a) Rate of growth	*g/day*	54	203
b) Slaughter weight	*kg*	30	362.5
c) $\frac{a}{b} \times 100$		1.80	0.56
d) Carcass yield	%	51	45
e) Age at slaughter	*years*	1.5	4.5
Meat production efficiency [1]		10.2	36.2

[1] $\frac{b \times d}{e}$ = kg carcass/animal/year

dition of consuming this meat during Lent and Easter week. The hunters are the "llaneros" of the Colombian and Venezuelan llanos; they work for a contractor who has a camp and often a hunting licence. Generally five or six capybaras are captured at a time, depending on their abundance and the location. But more are captured in the open savanna, where herds can be brought together and the animals selected for slaughter; each hunter may then kill between 50 and 100 animals. In the neighbourhood of channels or lagoons where the animals can take to the water, they are killed by spearing or shooting. When the animal is killed, the head and extremities are removed and the carcass flayed and boned, leaving almost all of the meat (about 85 percent) in one piece called a "lonja," which weighs 15 to 25 kg. The lonja is taken to the camp where it is washed, salted and dried by other llaneros. This involves the use of about 4 kg salt and four to six days of drying to produce a fully dried carcass. The salted meat is then done up in packages of 50 kg, containing four to seven (but more usually six to seven) pieces. The meat is marketed in March and April at the equivalent of about $2.00 per kg of dried meat.

In Venezuela the hide is seldom used, but in Brazil, Uruguay and Argentina the capybara is hunted almost exclusively for its excellent hide, which has the property of stretching in one direction only and is therefore much sought after by glove makers; capybara hides today command a good price on the world leather market. In Venezuela almost all the hides are wasted because there is no industry with the technology to process them. But in Colombia a suitable process has been developed for producing luxury leather that is sold on the Paris market.

Research in Venezuela is currently focused on the industrial processing of the meat and hide. Excellent results have been obtained in the production of Spanish-type sausages, Italian-style mortadellas, frankfurters, and German-style smoked chops. The importation of pork for sausage making could be discontinued if efficient use is made of the capybara.

Limitations

There are, of course, limitations to the use that can be made of this animal resource. The most important are the competition between capybaras and domesticated animals for the available food supply, and the possibility that the capybara may become a reservoir of some cattle diseases.

As justification for eliminating the capybara, it has been alleged that it competes with cattle for the best pastures (Estrada, 1966) and that it destroys sugarcane and rice plantations (Nogueira-Neto, 1973). But the studies by Escobar and González Jiménez (1973) to determine the forages grazed by capybaras, cattle, horses and deer have shown that during the period when competition was most likely — the recession of the flood waters and the onset of the dry season — there was little competition, as shown by the food preference of the different animals (Table 6). The capybara preferred *Paratheria prostata* and plants of the family Cyperaceae, whereas cattle preferentially grazed *Axonopus* species and *Panicum laxum*. The index of dissimilarity between the diets of these animals in respect of their lowland forage contents was found to be 0.95 (when 0.00 represents total similarity and 1.00 dissimilarity).

Table 6. **Proportions of plant species in total weight of food ingested by different animals at the beginning of the dry season**

Plant species	Capybara	Cattle	Horse	Deer
Hymenachne amplexicaulis	25	20	22	2
Paratheria prostata	17	1	8	1
Leersia hexandra	15	19	21	1
Sporobolus indicus	9	13	6	1
Panicum dichotomiflorum	5	5	2	1
Axonopus sp.	4	14	20	0
Luziola sp.	2	1	4	1
Panicum laxum	1	16	2	0
Panicum junceum	1	1	1	0
Setaria geniculata	1	2	4	1
Oryza perennis	1	1	1	0
Panicum zizanioides	1	1	1	1
Eragrostis acutiflora	1	1	1	0
Paspalum chaffanjonii	1	2	1	1
Paspalum orbiculatum	1	1	1	1
Cyperaceae	16	3	4	1
Eichhornia sp.	2	0	0	0
Others, including unidentified species	3	4	5	2
Dicotyledons	0	0	0	93
Those in proportion of under 1 percent add up to:	1	1	2	1

Sausages made from capybara meat

Not only does the capybara not compete with cattle, but it actually complements the latter in achieving an almost total use of the primary production of the flood plain ecosystem. It preferentially grazes the swamp, a physiographic unit that remains inundated almost all year round and is therefore not suited to grazing by cattle.

In Venezuela, Rangel (1905) observed that entire herds of capybaras were infected by a disease called "derrengadera," the causal agent of which was identified as *Trypanosoma equinum*. In Brazil, too, it has long been known (Santos, 1952; Hipolito *et al.*, 1965) that capybaras and horses cannot be raised together. But in view of the limited local importance of horses nowadays, this is of little consequence. Studies are now in progress to determine whether the capybara is a reservoir of leptospirosis, encephalomyelitis and, in particular, brucellosis. Serological examination of over 500 capybara blood samples by Plata (1973) showed positive reactions to *Brucella* in 30 percent of the cases, with female reactors outnumbering male. It is not known, however, whether there is any transmission of

the disease from capybaras to cattle or *vice versa*; A. Bello (1975, personal communication) is conducting an intensive study of the problem because of its importance in raising cattle and capybaras together.

Domestication

Nogueira-Neto (1973) has drawn attention to the fact that as early as 1565 Father Anchieta reported on the domestication and breeding of the capybara in Brazil, thus suggesting that they were used as domestic animals by the indigenous population. However, current efforts are devoted to exploiting them in their natural non-domesticated state so that their full ecological potential may be harnessed. In Colombia work aiming at the realization of the potential of the capybara in captivity is in progress, and guidelines for raising them on breeding farms have been provided (Cruz, 1974; Fuerbringer, 1974).

Recently weaned domesticated capybara in Misiones province, Argentina. (Photo: N. Schlaien)

Conclusion

The extraordinary meat production potential of the capybara should be more fully utilized in the future. As Pirie (1967) has pointed out, it is the animal best adapted to life on flood plains, it requires the smallest investment per unit of meat produced, and it has a reproductive rate that cannot be equalled by any existing domestic herbivore, even with the most sophisticated methods of improving reproductive efficiency that are available.

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Screwworm eradication in Puerto Rico and the Virgin Islands

by Donald L. Williams, S.C. Gartman and James L. Hourrigan

This article gives the history of screwworm eradication and research in the United States and describes the programme for eradication of screwworms from Puerto Rico and the Virgin Islands. This successful programme may be viewed as a model for other tropical countries of the Western Hemisphere where screwworms continue to be a problem.

Description and distribution

The screwworm is the larval stage of the fly *Cochliomyia hominivorax* (Coquerel). It is an obligate parasite in which the female oviposits on any type of wound or abrasion in live warm-blooded animals, including man, causing myiasis (Baumhover, 1966). The eggs hatch within 24 hours and the larvae eat into the tissues. They leave the wound after five to seven days and burrow into the soil to form pupae. The adult flies emerge in seven to 10 days. The females may mate at two days of age and begin to oviposit four days later. The usual life cycle is three to four weeks, with the adult flies living 10 to 14 days. The pupal stage may persist for as long as two months in cool weather. The adult males and females feed on nectar and pollen. The female obtains protein from animal wounds. Some temporary local immunity to reinfestations was demonstrated in the healed wounds of previously infested guinea-pigs (A.H. Baumhover, 1975, personal communication). However, female screwworm flies prefer to lay their eggs on unhealed, infested wounds of livestock, and any immunity that may be present is apparently not significant.

Screwworms are not found in cold-blooded animals or in the carcasses of dead animals, unless infestation originated prior to death. Maggots found in such locations are usually larvae of common blowflies (e.g. sarcophagids, which are not uncommon, and houseflies, which occur occasionally). *C. hominivorax* is found only in the Western Hemisphere, primarily in the southern United States, Central America, the Caribbean islands, and South America as far south as Argentina. Freezing winter weather eliminates the pest temporarily, but during warm weather the insect spreads in great numbers into more temperate climates. The adults have been found to fly up to 288 km (Hightower *et al.*, 1965) and larvae may be carried great distances when infested animals are transported. In the United States screwworms have been reported as far north as the states of Minnesota and Wisconsin. *Chrysomyia bezziana*, the Old World screwworm fly, is similar to *Cochliomyia hominivorax*, but is found only in Africa and the Orient.

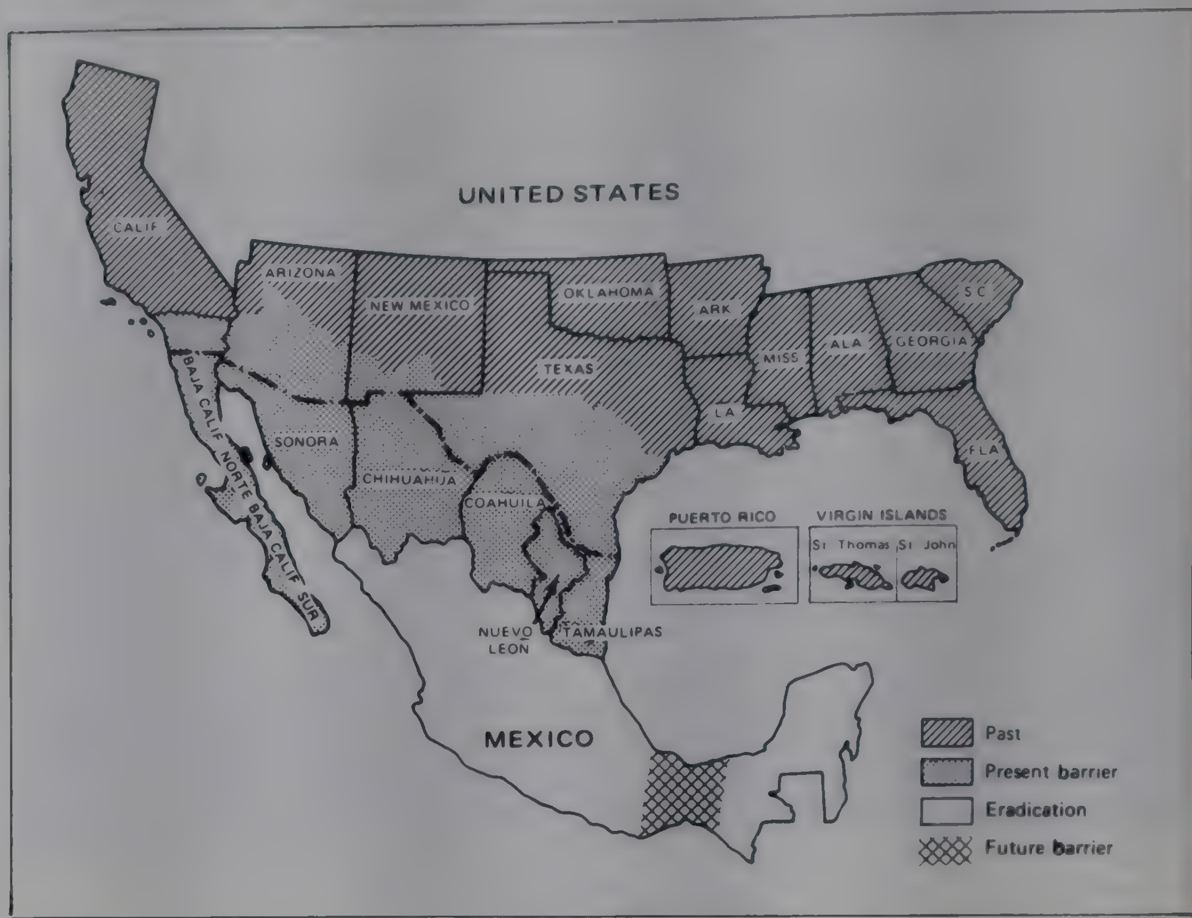
The authors are with the Animal and Plant Health Inspection Service, Federal Center Building, Hyattsville, Maryland 20782, United States.

Screwworm research and eradication in the United States

When E.F. Knipling first proposed the use of laboratory-reared and sterilized male screwworm flies as a tool for insect control or eradication in 1938, it represented a dynamic departure from the known chemical methods of insect control (Knipling, 1955). He later developed a theoretical model of insect population reduction following release of an overwhelming number of sterile insects into a given population. It was theorized that in four generations normal reproduction could be eliminated. The knowledge that gamma radiation could be used to sterilize the insect made possible a practical application of the theory. Exposure of six-day-old screwworm pupae to 6 000 r of gamma radiation sterilized both sexes and prevented oviposition by the female (Bushland and Hopkins, 1951; 1953). As the female, which normally mates only once, is mated to a sterile male, the eggs do not hatch and the life cycle is broken.

In 1954, the technique of releasing sterile flies from airplanes over infested areas was used to eradicate screwworms from Curacao, a Caribbean island with an area of about 440 km^2. In the United States the sterile male technique was used in 1959 to eradicate screwworms from Florida and the southeastern states. The insect usually overwintered in a 129 500 km^2 area of southern Florida, spreading into the southeastern states each year during warmer weather. In February 1962, production and aerial release of sterile screwworm flies was begun in an effort to eliminate screwworms from Texas, New Mexico, Oklahoma, Louisiana, and Arkansas. By February 1964, overwintering populations of screwworm flies had been eradicated

Screwworm eradication programmes in the United States and Mexico



from these five states. In both the southeastern programme and the southwestern programme the sterile male technique was reinforced by conventional animal disease eradication techniques, including inspection of livestock, spraying of animals with insecticides for prevention and treatment, hand treatment of wounds with livestock powder or smears, control of animal movements, and a strong public information programme enlisting owner cooperation for treating and reporting infestations.

By April 1966, overwintering populations of screwworms had been eradicated from California and Arizona, thus freeing the entire United States. A barrier of sterile flies was established along the United States-Mexican border from the Pacific Ocean to the Gulf of Mexico to protect livestock in the United States from migrating populations of fertile screwworm flies from Mexico. This barrier programme has reduced livestock losses from screwworms to a small fraction of that experienced prior to the initiation of the programme in 1962. However, the barrier is not impenetrable, and some gravid females do penetrate it and re-establish centres of infestation in the United States. Hence the United States and Mexico are initiating a cooperative programme to push native screwworm populations southward from the present 3 200 km-long barrier to a new and much shorter barrier at the Isthmus of Tehuantepec.

Eradication from Puerto Rico and the Virgin Islands

With the elimination of the overwintering populations on the mainland, Puerto Rico and the Virgin Islands were the only areas under United States jurisdiction where screwworms continued to be a serious problem. Losses from screwworm infestations were costing Puerto Rican consumers and livestock producers an estimated U.S.$2.5 million a year. These losses were the result of weight loss and carcass damage at slaughter, cost of medication for treatment, death losses, damage to hides, and cost of husbandry labour. Cases in humans were occasionally reported (Fox *et al.*, 1965). Animal health officials and livestock owners requested assistance, and the Animal Health Division of the Agricultural Research Service agreed to cooperate in eradicating screwworms from Puerto Rico and the Virgin Islands. The experience gained from eradicating screwworms in a tropical environment with a high animal population was expected to be valuable for subsequent application to the tropical regions of Mexico.

Because screwworm flies could fly between some of the Virgin Islands, and because they might be introduced by infested livestock shipped from other islands in the Caribbean, both the United States Virgin Islands and the British Virgin Islands were included in the eradication programme.

Puerto Rico has an area of about 9 065 km^2. It has a total livestock population of 774 500, which according to the 1966 census consisted of 550 000 cattle, 200 000 pigs, 14 000 horses, 10 000 goats and 500 sheep. This represents about 500 domestic livestock per square km, not including the population of domestic and feral dogs which also serve as screwworm hosts. When considering the land area used for crops and the degree of urbanization, the number of hosts per square km was even greater. The climatic conditions in this tropical area were very conducive to screwworm survival. The ideal climate and large number of potential hosts made eradication a difficult proposition.

It was not possible to determine when screwworms first invaded Puerto Rico. No doubt the parasite had been present for a considerable time. The resulting isolated populations of screwworm flies could have evolved to the extent that the Puerto Rican strain of flies might not mate with sterile insects developed from mainland strains. To check this possibility, Agricultural Research Service scientists made three collections of Puerto Rican screwworms which were tested in the Service's laboratories at Mission, Texas (A.H. Baumhover, 1975, personal communication). These tests, conducted in small cages in the laboratory, proved that the sterile males produced at Mission did mate effectively with native Puerto Rican flies. For the programme to work effectively, sterile males must outnumber native males and must also compete successfully with native males in mating with native female flies. The continued release of sterile flies reduces and ulti-

mately eradicates screwworms from the area.

Role of the U.S. Air Force. The U.S. Air Force provided support for aerial release of sterile flies for the programme. Personnel of the U.S. Air Force Special Warfare Center at Eglin Air Force Base, Florida, together with U.S. Air Force Headquarters personnel at the Pentagon, Washington, D.C., cooperated with the U.S. Department of Agriculture, the Commonwealth Government of Puerto Rico, and the Governments of the United States and British Virgin Islands in the design and planning of the screwworm eradication programme in Puerto Rico and the Virgin Islands. The Air Force was especially interested in the programme, since a mission of the Special Air Warfare Center is to apply modern aircraft operation techniques to assist other governments. This programme was similar to other successful civic action programmes that the Air Force has undertaken throughout the world in aid projects. In July 1973, the Air Force Group at Eglin Air Force Base was replaced by units from the U.S. Air Force reserve, and the latter became responsible for the aerial operations until sterile fly release was successfully concluded on 3 May 1975. All Air Force participation was characterized by an extremely high level of professional competence and safety. Without such cooperation, the programme could not have succeeded.

Strains of flies. The Puerto Rico-Virgin Islands programme started in June 1971, using a "Mexican" strain of fly. This was changed in September 1972, and flies from both a "Texan" strain and a "Puerto Rican" strain were released. During 1973, these two strains varied in quantity, but only the Puerto Rican strain was released on the island of Vieques. In January 1974, the Puerto Rican strain was discontinued and the "Tex-Mex" strain was used until it was replaced with the "FF-8" strain in February 1974. The Tex-Mex strain was developed with flies collected from Mexico and the United States. The FF-8 strain was developed from field collections from southern Texas and northern Mexico. Screwworms were eradicated from the British and United States Virgin Islands and the island of Culebra using the Mexican strain, from the islands of Vieques and Mona using the Puerto Rican strain, and from western Puerto Rico using both the Tex-Mex and Puerto Rican strains.

Sterile fly release operations. Sterile screwworm flies were produced at Mission, Texas, by the Veterinary Services of the U.S. Department of Agriculture's Animal and Plant Health Inspection Service. Beginning in June 1971, the irradiated pupae were packed in trays and racks, put in a large environmental chamber chilled to 7-12.7°C, and shipped to Puerto Rico via a U.S. Air Force C-123 aircraft. The flights to Ramey Air Force Base in Puerto Rico took from 14 to 16 hours, excluding stops for fuel and crew changes. Pupae were packed at the base, held until the adult flies emerged, and dispersed by small single-engine U-10 aircraft. The payload was relatively small, about 150 boxes per sortie.

Beginning in July 1971, 2.5 million pupae were shipped each week. This was increased to 5 million in September 1972 and further increased to 14.5 million in February 1973. While 2.5 million pupae per week were being airlifted, screwworms were eradicated from the United States and British Virgin Islands, as well as the island of Culebra, which is 32 km off the eastern coast of the main island. Vieques, about 14 km to the southeast, was free of screwworms by July 1973. During some periods as many as 8 500 sterile flies per square km were distributed over Vieques. Mona Island, 72 km due west, was also freed from infestations. Screwworms were believed eradicated from western Puerto Rico during the first 28 months of the programme.

In July 1973, due to problems in fly quality and inadequate ground support activities, the C-123s were replaced by the larger, longer-range C-130 aircraft, and preboxed sterile pupae were shipped from Mission to Puerto Rico. The aircraft is pressurized, and the flies were held in temperature-controlled conditions to preserve fly quality during transportation. The nonstop flight lasted about six hours. Upon arrival at the distribution centre, the dispersal boxes were placed in a modular air-conditioned chamber initially maintained at 25.5 to 26.6°C. When 90 percent emergence had occurred, the temperature was lowered to 18 to 20°C. Distribution of the flies began early the following morning. Two C-7 aircraft, each loaded with about 3.5 million flies per sortie, made drops on the predetermined flight lanes and over special areas as directed. Any flies remaining were held at 15.5 to 18°C until re-

A calf infested with screwworm larvae

Table 1. **Sterile flies released over Puerto Rico, Vieques and the Virgin Islands**

Time of release	Flies released
1 June - 31 Dec. 1971	77 600 000
1 Jan. - 31 Dec. 1972	180 860 000
1 Jan. - 31 Dec. 1973	701 440 700
1 Jan. - 31 Dec. 1974	722 400 000
1 Jan. - 3 May 1975	169 008 000
Total flies released	1 851 308 700

SOURCE: U.S. Department of Agriculture.

leased. Careful examination of the condition of the flies was conducted at each stage of this operation, and quality control tests were made routinely to monitor fly quality. Quality improved after July 1973 with a higher percentage of emergence and an apparent increase in longevity and activity.

During most of 1974, 14.5 million sterile flies were released over Puerto Rico and Vieques per week. About 10 million sterile flies were dropped on the lanes at a rate of 8 750 flies per square km. The island was transected longitudinally by 16 lanes about 3 km apart. These lanes were traversed every other week. Special drops over outbreak areas required an additional 3.5 to 4 million flies per week. Ground releases were also made in canyons and at the base of mountains in order to ensure that sterile flies reached these areas (Corristan, 1974). Air Force personnel developed an electronic box counter to ensure that the required numbers of sterile flies were evenly distributed over infested areas. The numbers of sterile flies released over Puerto Rico, Vieques, and the Virgin Islands are recorded in Table 1.

Screwworm case detection effort. There was no efficient lure to attract screwworm flies into fly traps. The best attractant available was decomposed liver. It attracted primarily the female; males represented less than 5 percent of the screwworm catch. This lure was not specific for screwworm flies and attracted several thousand ordinary blowflies for every screwworm fly. This made identifying trapped flies a laborious task because of the similarity to the secondary screwworm, *C. macellaria* (Fabricius). There was no efficient way to measure the wild populations of screwworms or to evaluate the behaviour and efficiency of the released flies in the field. The best practical measure of programme efficiency was from comparisons of laboratory-confirmed screwworm cases. Only case reports accompanied by larval specimens were considered when determining screwworm incidence, unless study indicated a high probability that an infestation had actually occurred. At least 75 percent of the screwworm samples in 1974 were collected by Puerto Rican or United States livestock regulatory personnel. The remainder were obtained by livestock owners or their employees. It was difficult to maintain high reporting efficiency by the latter group.

The last screwworm case in Puerto Rico was reported on 5 November 1974. The reporting of non-screwworm samples was used to evaluate the efficiency of the screwworm case detection system in Puerto Rico. In the first nine months of calendar year 1975 no screwworm cases were reported (Table 2), but there were 19 laboratory-confirmed non-screwworm cases. Continued vigilance has not revealed evidence of any additional screwworm cases in Puerto Rico.

Egg mass sterility data. Sterility data also provided a measure of the effectiveness of released sterile males. This was difficult and time-consuming. Several pens of infested or wounded animals were maintained periodically during the first two years of the programme in Puerto Rico, Vieques and in St. Thomas (United States Virgin Islands). Sterility was disappointingly low, indicating insufficient numbers of competitive released males. Following the changes in release procedures noted above, particularly the shortening of the interval between irradiation and release, sterility increased to 88 percent. This was adequate to cause a downturn in native populations and eventual eradication.

During the final phase of the programme in Puerto Rico when the screwworms appeared to have been eliminated, monitoring for egg masses was greatly increased to determine sterility, and also to verify the absence of screwworm activity. Livestock owners assisted by penning susceptible wounded animals which were not treated. Highly attractive new-born calf navels were used, along with wounded animals, in the 46 pens established throughout the island. Fortunately, the native screwworm population had become extremely low or non-existent, and no collections were made.

Table 2. **Confirmed screwworm samples (including fertile egg masses)**

Calendar year	Puerto Rico (including Vieques, Mona and Culebra)	U.S. Virgin Islands	British Virgin Islands
1971	1 833	94	13
1972	2 240	2	16
1973	1 303	0	0
1974	168	0	0
1975	0	0	0

Problems. There were two major problem areas during the first two years of fly release: poor fly quality and inadequate ground support activities.

The first problem involved delivery of sterile flies of good quality for release over Puerto Rico. Lack of airplane pressurization and temperature control during the long flight from Mission to Puerto Rico resulted in damage to the pupae. Accumulation of the heat generated by pupae metabolism caused the most serious damage. This was further compounded by the fact that the flies had to be packaged in Puerto Rico and stored up to 10 days prior to release. The use of a small, single-engine U-10 aircraft (Helio-Courier) further delayed release. Laboratory tests have shown decreases in longevity of adult flies corresponding to increases in holding times in the pupal stage. The delayed releases are believed to have weakened the flies and limited their effectiveness.

This problem was alleviated in July 1973 when the U.S. Air Force replaced the C-123 aircraft with a larger pressurized C-130 as a pupae-hauling aircraft. All flies released after that time were packaged at Mission and shipped to Puerto Rico by C-130 aircraft. The C-7 (Caribou) aircraft replaced the U-10 for fly distribution. The C-7 was not air-conditioned, but the flies were cooled by air circulation on the ground by opening the front hatch and the large rear door. During flight, the rear door also remained open to maintain adequate cooling. There was no build-up of heat above ambient temperatures in this aircraft. Flies were released at an altitude of 457 metres above the terrain.

The second problem concerned the need to stimulate owner cooperation for animal inspection and the collection and submission of larval samples for identification.

Midway during the programme, the Extension Service in Puerto Rico was asked to intensify the public information programme, and their efforts stimulated owner participation. There was an increase in owner activity that helped to improve ground support activities, such as spraying infested and adjacent herds with a 25 percent coumaphos spray. A total of 73 374 animals were sprayed during calendar year 1973 and 49 255 in 1974, compared to only 2 987 animals sprayed during 1971-72 (Table 3).

This spraying was of inestimable value in helping to reduce screwworm populations in outbreak areas and proved to be a valuable adjuvant to the sterile male technique.

Table 3. **Livestock sprayed with coumaphos**

Year	Number of cattle sprayed
1971	0
1972	2 987
1973	73 374
1974	49 255
1975 [1]	11 300

[1] Through June.

The island of Vieques (32 km long and 3 to 5 km wide) was particularly troublesome. There were more than 20 000 head of livestock on the island, which had large restricted areas used by the U.S. Navy and U.S. Marines for military training. A significant number of livestock would wander into these areas and be wounded by military explosions or training paraphernalia, thus becoming a continuing source of screwworm infestation. They were ultimately rounded up with helicopters for inspection and treatment. (Helicopters were used because of the numerous unexploded shells in the impact area, which made it unsafe for personnel to enter). After the animals were removed from the impact area, the fence surrounding the area was repeatedly repaired to prevent livestock from re-entering. Livestock inspectors equipped with dart guns using CO_2 as propellant immobilized animals which were suspected of having screwworm infestations. Any wounds found were treated with insecticidal smears. Navels of new-born calves were also treated in this manner. On Vieques 194 animals were immobilized in 1973 with dart guns and treated for screwworms.

Epizootiology. Epizootiological investigation played an important role in the programme. When screwworms persisted after the first year of sterile fly release, it was suspected that both sterile and fertile flies were finding a very favourable habitat. Flies did not have to move far to find food, shelter, or wounded animals. The presence of a dense livestock population comprising many animals with wounds attractive to screwworm flies supported the theory that the flies did not migrate as far in Puerto Rico as they did in southern Texas. Field inspection revealed that packs of stray dogs which gathered around garbage dumps in search of food were causing bite wounds which helped to perpetuate screwworms. The humane elimination of portions of the dog population undoubtedly assisted the programme. A single case in a horse, undetected and untreated for several weeks, helped to prolong the infestation. Restriction of animal movements, a standard regulatory technique, was not used in the Puerto Rican programme.

The importance of good epizootiological field work cannot be overemphasized in any attempt to eradicate screwworms from a given area.

Summary

The sterile male technique was chiefly responsible for the eradication of screwworms from Puerto Rico and the Virgin Islands. However, the technique is dependent on a vigorous programme of ground support which includes conventional methods of animal disease eradication. This includes inspection of livestock, collection and submission of larval samples, spraying of affected animals with an approved pesticide, good epizootiology, and a vigorous public information and education programme to enlist the cooperation of the livestock owner.

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Veterinary control and sanitary

by Y. Zamberg and J.E. Lancaster

In recent years, the introduction of new mechanical procedures involving large equipment into the modern hatchery has made it necessary to place greater emphasis on routine management and hygienic precautions. With the progressive development of the poultry industry within a country, hatcheries become larger in size, and many operate continuously without a break throughout the year. This situation is the result of the large increases in the number of eggs set and hatched. In order to meet demand and utilize expensive equipment more economically, more than one hatch per week may be planned.

The marked increase in output of day-old chicks necessitates a corresponding increase in related services and operations. These services include the movement of personnel and vehicles in and around the hatchery building. All these factors and movements demand precise planning of all hatchery operations to ensure maximum sanitary standards. The work flow in hatchery design, the production of clean hatching eggs and the dispatch of strong disease-free chicks are the basic aims of the hatchery sector of the poultry industry.

Hatchery design and work flow

Hatchery layout should include physical separation of each major operation within the building. This means that each operation should be integrated, but not centralized into one unit. As far as can be arranged, the movements involved in the production of chicks should be in one direction only. Cross currents of air must be reduced to a minimum. The best results are achieved in hatcheries which have separate rooms for reception of eggs, fumigation, setting, hatching and removal of chicks. Washing facilities, storage rooms and offices must be separate. Lack of adequate working areas and poor design of equipment and facilities make cleaning difficult, resulting in a level of contamination.

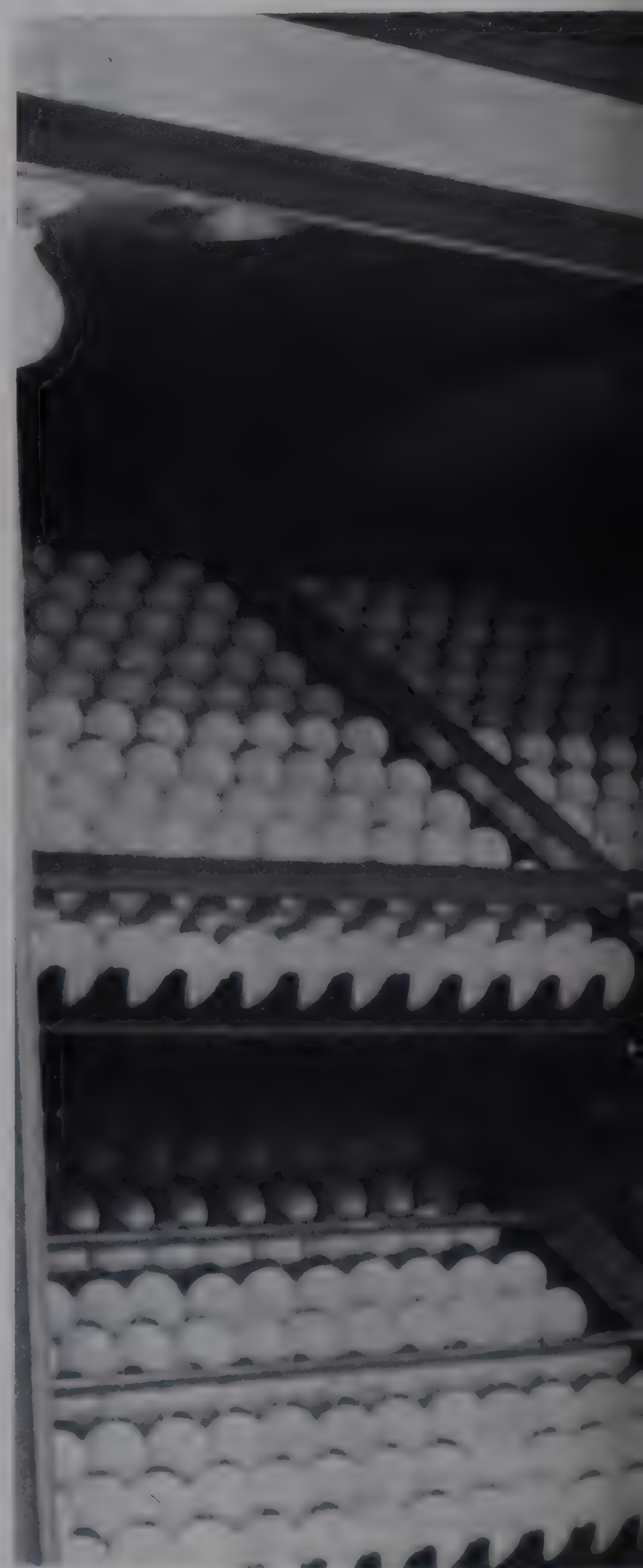
This contamination includes the microorganisms present in soil, feathers, litter, egg boxes and on other items of equipment, including the clothing worn by the hatchery workers. To reduce the exposure of the newly hatched chick to these sources of contamination, the hatchery must be designed for efficient work flow. This means that the hatching eggs must be moved through the hatchery in a methodical manner: from the receiving area, the eggs move to the room with the setting machines, then to the room with hatching machines, and finally to the chick boxing room and the loading dock.

Subsidiary to this main flow of hatching eggs and chicks are secondary rooms or areas for fumigation of eggs, washing of hatcher trays and movable equipment, and a room for the storage of chick boxes and other equipment.

Wherever possible, each room should be ventilated separately and the incubators and hatchers should be ventilated with air that has passed through a dust filter. The air from the hatching machines should be exhausted out of the building and away from the air intakes.

Generally, the following air movements are recommended:

1. In the egg setter room it is necessary to replace 0.15 to 0.20 cubic metre per minute per 1 000 eggs in the machines.
2. The hatcher room requires more air movement, i.e. 0.40 to 0.60 cubic metre per minute per 1 000 eggs.
3. The chick processing room needs the greatest air movement, i.e. 0.60 to 0.70 cubic metre per 1 000 chicks.



Y. Zamberg *is with Veterinary Services, Bet Dagan, Israel.* J.E. Lancaster *is with the Health of Animals Branch, Ottawa, Canada.*

outine in hatchery operations

In warm climates and in the absence of echanical cooling, much larger volumes of r will have to be moved. In order to fa-itate hygienic control and ensure produc-on of good quality chicks, mechanical air onditioning is very useful because the air input and air exhaust can be controlled accurately. The use of areas with a positive air pressure facilitates correct air circulation and prevents contaminated air from flowing from rooms or areas with higher microbial contamination.

Identifying eggs in setter machine

There are many areas in the hatchery on which dust and dirt accumulate readily, e.g. the space between, behind and on the top of incubators and hatching machines. Often dust and dirt can be found inside air ducts. In small hatcheries with poor ventilation systems, studies have shown that moulds and pathogenic bacteria originating generally in the washing and disposal areas have been carried by the ventilation system into the incubator rooms. Spores of the mould *Aspergillus fumigatus* have remained viable at room temperature for at least 18 months in hatchery dust. It has been shown that embryos become infected with bacteria and moulds during incubation, and also that newly hatched chicks are very susceptible to infection with various microorganisms such as salmonellae, *E. coli*, *Pseudomonas* species and *A. fumigatus*.

It has been demonstrated by Williams *et al.* (1968) that cracked eggs facilitate a marked increase in egg shell penetration by *Salmonella typhimurium*. These authors emphasize that a single infected egg can contaminate large batches of clean eggs when the egg is accidentally broken, or as hatching occurs. *E. coli* is another potentially pathogenic organism which can behave in a similar manner (Reid *et al.*, 1961).

As an example of the magnitude of the microbial problem that can face a hatchery, it has been found that a single egg can carry up to 30 000 microbes on the shell. The increase in numbers of microorganisms inside the hatchery is aided by the working temperature and humidity.

The process of hatching and the work involved in removing the chicks are accompanied by a massive increase in microbial numbers which originate from dead embryos, pipped eggs, hatcher dust and fluff, and the activ-

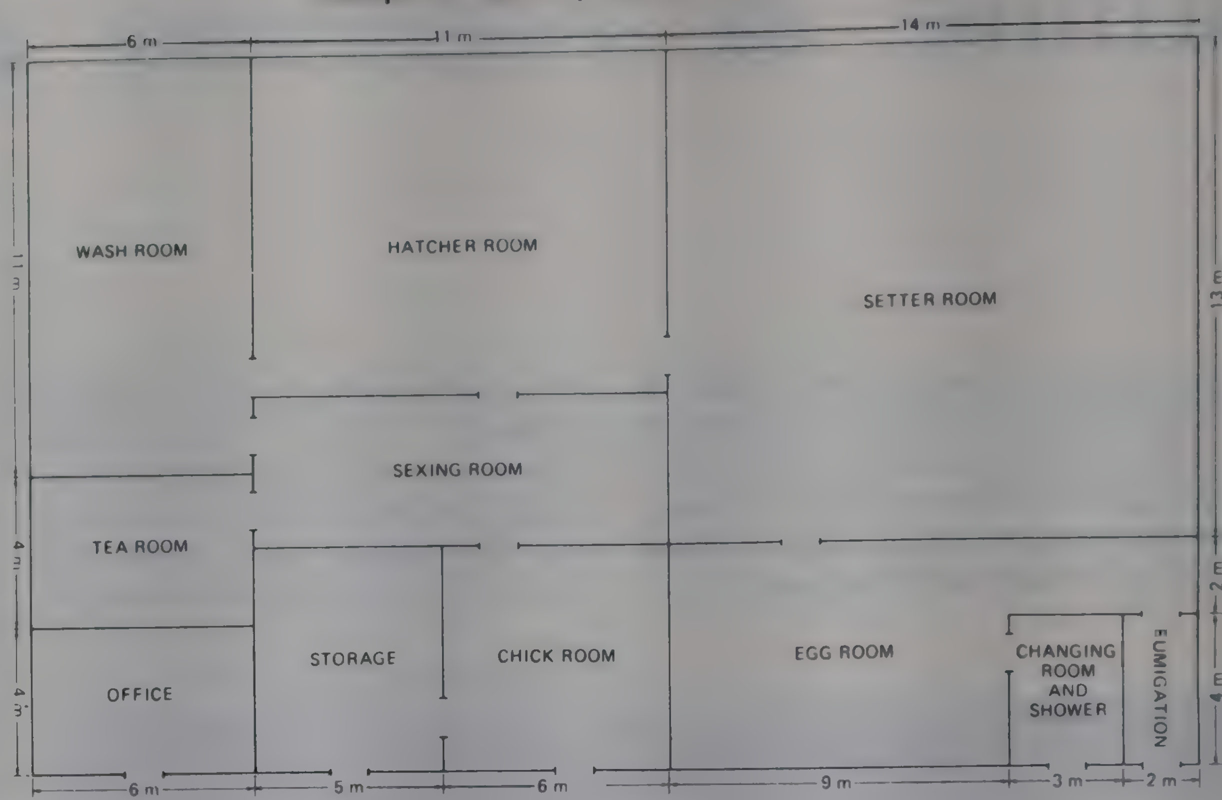
ities of the personnel. These factors influence the level of microbial contamination of the chicks as they hatch, and affect their subsequent health and livability, especially during the first few weeks of life.

A major source of contamination within the hatchery is the low sanitary condition of the hatching eggs on arrival at the hatchery. The level of cleanliness of the hatchery therefore depends to a large extent on the hygienic standards of the laying flocks and, in particular, on the regular and frequent collection of the eggs. Each hatchery should make it mandatory that only clean eggs be set. These eggs should be fumigated on the farm as soon as possible after collection in order to destroy microorganisms before they have time to penetrate through the egg shell. The fumigated eggs must be packed in cases and "filler flats" which are also free from dust and dirt. It follows, therefore, that hatchery personnel should adopt routine sanitary procedures, both in the hatchery and on the supply farms, in order to prevent the development of hatchery sanitation problems rather than attempt to solve these problems after they have arisen.

Contamination of the hatchery can also occur from the immediate environment. The spread of Newcastle virus from contaminated vehicles has been recorded. Consequently, the importance of locating the hatchery as far as possible from other buildings that house livestock, and poultry in particular, requires special emphasis. The disinfection of vehicles and outside equipment must also be an integral part of hatchery routine.

Cleaning of the hatchery and the surrounding environment should be conducted regularly. Within the operating parts of the hatchery, the floors, walls and ceilings must be of a hard finish and suitable for washing by water applied under pressure. Similarly, the immediate surroundings of the building must be of concrete or a similar impervious material, with adequate drainage. The drainage from inside and outside the hatchery must be designed to protect the environment from any pathogenic bacteria, viruses and moulds carried in the effluent.

Example of hatchery design and work flow



Cleaning and fumigation

Washing prior to disinfection is necessary because the presence of organic matter such as soil, dust, feathers and litter protects harmful organisms from the action of chemical disinfectants. In some instances, this organic matter will actually inactivate certain types of disinfectants. Thus, an adequate supply of water is necessary for the cleaning of the hatching areas and machines, the chick boxing area and some permanent and movable equipment. Cleaning of the floors, walls and equipment requires that adequate drainage for the water be available and suitably located.

Certain equipment cannot be cleaned with water under pressure, e.g. fibre egg trays and boxes. It is encouraging to note that plastic egg trays, wooden egg boxes and plastic chick containers are becoming more widely used. This material can be easily cleaned with water and detergents, and if necessary subjected to a final disinfectant or to fumigation. As an additional and very necessary precaution against the dissemination of disease agents, egg boxes and egg trays should be identified with the flock producing the hatching eggs and returned to that flock only after cleaning has been completed.

Other areas within the hatchery do not lend themselves to the use of water under pressure. These include the tops of incubators and hatching machines, electrical equipment and controls, ledges, tables and other horizontal surfaces. These surfaces, which readily collect dust and debris in which microorganisms multiply rapidly, should be reduced to a minimum. The remaining horizontal surfaces must be cleaned regularly. For this purpose, a commercial type vacuum cleaner may be used. Following this, disinfection can be conducted by the use of a disinfectant solution in a spray form (Harry, 1955). For cleaning measures of this kind, an aerosol generator is a useful item of equipment.

It is evident from the above that routine fumigation by itself is no longer sufficient. Nevertheless, fumigation using formaldehyde (formalin) as a fumigant has proved to be a very effective means of destroying microorganisms on eggs, egg cases, setters, hatching machines and fibre chick boxes, provided that these items have been subjected to preliminary cleaning.

Use of formaldehyde gas

Requirements for proper fumigation. Four requirements must be met if maximum germicidal activity from formaldehyde is to be obtained:

1. *Temperature.* The maximum effect is achieved in the temperature range of 24 to 38°C.

2. *Humidity.* This is essential for maximum effect, and a wet bulb reading of 20°C or higher is recommended.
3. *Time.* The time required to kill the microorganisms depends on the temperature, humidity and the concentration of formaldehyde.
4. *Concentration.* The use of potassium permanganate to liberate formaldehyde gas is desirable because it produces an instantaneous expulsion of gas to produce a maximum concentration.

To produce the fumigant, one part (by weight) of potassium permanganate is mixed with one and one half parts (by volume) of formalin. When the proper mixture of formalin and potassium permanganate is used, a dry brown powder will remain after the reaction is completed.

Recommended concentration. A concentration of 53 cc formalin and 35 g potassium permanganate per cubic metre of space is recommended. These amounts are effective if the temperature and humidity are at the recommended levels and the space is fumigated for 20 minutes.

To calculate the amounts of chemicals necessary, measure the inside of the incubator or fumigation cabinet or room (i.e. length × width × height). The space occupied by trays or eggs or articles to be fumigated is not important.

Neutralization of formaldehyde gas. Ammonium hydroxide is used at an amount equal to half the volume of formalin used. This will neutralize the formaldehyde gas in 10 to 15 minutes.

Precautions. Keep formalin at room temperature in a tightly sealed container to prevent it from losing strength. Do not store formalin for long periods, as a white precipitate (paraformaldehyde) will form. If this occurs, it should be mixed thoroughly before using. If storage is necessary, keep formalin in small, completely filled containers.

Always add the formalin to the potassium permanganate; never the reverse.

Formaldehyde at bactericidal concentrations is very irritating to the eyes, nose and throat. Hatchery personnel should use a respirator and avoid unnecessary exposure to the gas.

Use a proper container to release the gas. The sides of the container should slope outward to avoid an excessive buildup of heat that could ignite the formaldehyde. The container should be made of heatproof material such as metal or earthenware and should be sufficiently large to prevent the chemicals from boiling over.

Do not expose chicks or poults to the full concentration of the formaldehyde gas.

Fumigation of eggs

To reduce to a minimum the microbial penetration of the shell, eggs should be fumigated immediately after collection, and preferably while they are still warm.

The fumigation room or cabinet should be airtight and equipped with a fan to circulate the gas during fumigation and to expel the gas from the building.

The eggs should be collected loose in wire baskets or placed in plastic trays in a manner that will permit air circulation and exposure to the formaldehyde gas.

The temperature and humidity should be at the recommended levels.

The fumigation time should be at least 20 minutes. Experience has shown that fumigation for 60 minutes will not reduce hatchability.

The type of facility and fumigation procedure used with eggs, egg trays and cases at the hatchery is the same as that for fumigation of eggs on the farm.

Fumigation of eggs in setters. Eggs should be fumigated within 12 hours after setting when the temperature and humidity return to normal operating levels.

The setter doors and vents should be closed, but the circulation fan should be kept operating.

After fumigation for 20 minutes, the vents should be opened to the normal operating position in order to release the gas.

Warning: Do not fumigate eggs that have been incubated for 24 to 96 hours, because this can result in embryo mortality.

Fumigation of hatchers. Following removal of all the chicks and the cleaning and disinfection of the empty machine, the disinfected egg trays are replaced and the machine prepared for the next batch of incubating eggs. The doors and vents should be closed and the temperature and humidity returned to normal operating levels. Fumigation time should be at least three hours or preferably overnight, using the standard amounts of formalin and potassium permanganate.

Warning: The above fumigation procedure applies to a machine in which there are no hatching eggs. Eggs and chicks cannot be fumigated using the above fumigation time.

Fumigation of eggs in hatching machines. This is a common practice in certain areas and under certain conditions. The eggs should be fumigated after being transferred to the hatching machines and before 10 percent of the chicks have begun to break the shell. After transfer of the eggs, the hatching machines are permitted to return to normal operating temperatures and humidity. The ventilators are closed and fumigation is conducted with the hatching fans running. The standard amounts of formalin and potassium permanganate are used. Fumigation time is 20 minutes.

Neutralization of formaldehyde gas. This can be conducted with a 25 percent solution of ammonium hydroxide using an amount not more than one half the volume of formalin used. The ammonia can be spread on the floor of the machine and the doors closed quickly.

Use of formaldehyde powder (paraformaldehyde) as a fumigant

Paraformaldehyde can be used as a source of formaldehyde gas for fumigating eggs and egg cases. The method is effective provided the temperature and humidity are at the recommended

level. Thus the minimum temperature should be 24°C and a wet bulb reading of at least 20°C. Use 10.5 g paraformaldehyde per cubic metre. This quantity can be increased to 13 g paraformaldehyde per cubic metre. The conversion formula is 10 cc formalin to 2.5 g formaldegen (paraformaldehyde) powder.

Keep the generator operating until all the fumigant is released. Open the door to allow the gas to escape, or use ammonium hydroxide at the rate of 27 g per cubic metre to neutralize the formaldehyde gas.

Use of disinfectants

Anderson (1973) has stated that 90 percent of hatchery sanitation is represented by hatchery design, good management of the hatchery and supply flocks, cleanliness and a programme whereby dust is removed and prevented from reaching the hatching areas. The remaining 10 percent represents the additional hygienic measures provided by fumigation and disinfection.

It must be clearly stated that a disinfectant, whether it is used as a solution, gas or as an aerosol, will not compensate for faulty cleaning or for a hatchery inadequately designed to permit a thorough cleaning programme. Hygienic control in a hatchery is essentially cleanliness followed and aided by disinfection.

The general action of a disinfectant depends on the following:

1. *Concentration*. A disinfectant can kill bacteria (is bactericidal) at one concentration, but can only reduce the growth of bacteria (is bacteriostatic) at a lower concentration.
2. *Temperature*. The higher the environmental temperature, the more rapid is the destruction of the microorganisms by disinfectants.
3. *Time*. By increasing the length of time the microorganisms are exposed to a disinfectant, the number destroyed is increased.

The properties of five disinfectants commonly used for different areas in a hatchery are given in Table 1.

Table 1. **Properties and uses of disinfectants**

Properties	Chlorine	Iodine	Phenol	Quats [1]	Formaldehyde
Bactericidal	+	+	+	+	+
Bacteriostatic	—	—	+	+	+
Fungicidal	—	+	+	±	+
Virucidal	±	+	+	±	+
Toxicity	+	—	+	—	+
Activity with organic matter	++++	++	+	+++	+
Hatchery equipment	+	+	+	+	±
Water disinfection	+	+	—	+	—
Personnel	+	+	—	+	—
Egg washing	+	—	—	+	+
Floor	—	—	+	+	+
Foot baths	—	—	+	+	—
Rooms	±	+	±	+	+

NOTE: Number of + indicates degree of affinity for organic material and the corresponding loss of disinfecting action. + = positive property, — = negative property, and ± = limited activity for specific property.

[1] Quaternary ammonium compounds.

Means of determining the level of hygienic control

The preceding parts of this article outline manual and chemical means for maintaining a satisfactory level of sanitation within a hatchery. This degree of sanitation is dependent on the observer. It is impossible to see bacteria with the unaided eye. In addition, it is necessary to know whether the bacteria present are known to cause disease in poultry.

Once this gap in hatchery sanitation was recognized, various methods were devised for determining their sanitation status. To date, the methods in use depend on determining the number of viable bacteria in the air inside hatchery buildings and on tables, other surfaces and in the dust and fluff present at hatching time.

It was clearly demonstrated that microbial counts increased with the increased activity of removing and boxing chicks. One technique which has been used in Canada for more than 15 years is the microbiological examination of incubator fluff and dust collected after the chicks have been removed from the hatching machine (Wright *et al.*, 1959). A direct relationship was observed between the airborne population of microorganisms and the contamination of various surfaces (Lancaster, 1965; Magwood, 1964). Examination of dust and fluff samples has been used for the measurement of salmonella contamination in hatcheries (Miura *et al.*, 1964).

The bacterial contamination of horizontal surfaces, e.g. tables and building ledges, and of vertical surfaces such as walls and doors, can be examined by pressing solid agar on to the surfaces. For this purpose, Rodac plates or elongated rolls of nutrient agar (agar sausages) have been used (Daser Jutta, 1972; Ten Cate, 1963). Both the plates and rolls of agar are very useful where the distance between the hatchery and the laboratory is

Table 2. **Sanitation rating of hatcheries in Ontario province, Canada**

Year	Number of samples	A [1]	B [1]	Rating (A [1] + B [1])	C [1]	D [1]
				Percent		
1971	1 583	36.0	32.0	68.0	27.0	5.0
1972	1 479	35.0	25.0	60.0	29.0	11.0
1973	1 493	36.0	30.0	66.0	27.0	7.0
1974	1 176	51.7	32.3	84.0	16.1	0.5

[1] A, B, C and D represent the four ratings used.

Table 3. **Sanitation rating of hatcheries in Israel**

Year	Number of samples	Rating of samples		
		Very good	Average	Unsatisfactory
			Percent	
1972	17 580	10.6	29.3	60.1
1973	23 580	43.0	48.8	13.2
1974	22 260	55.5	35.6	8.9

relatively short. In addition, the agar technique gives a direct bacterial count per standard surface area. The fluff technique is useful where distances are greater and where the purpose is to maintain a microbiological surveillance programme within the hatchery.

Although the different laboratory procedures are not directly comparable, these techniques are of practical value in assessing in a standardized manner the progress which can result from the application of hatchery sanitation over a given number of years. For those involved in hatchery sanitation, these techniques form an essential part of a sound monitoring system.

Table 2 shows the sanitation ratings, based on a standardized bacteriological technique, of hatcheries in the province of Ontario, Canada (Epps and Anderson, 1975).

Similar techniques to determine the microbial density in hatcheries have been developed by other countries in different climatic zones. Data for Israel are shown in Table 3.

Discussion

The laboratory procedures used in Ontario, Canada cannot be compared exactly with the techniques used in Israel, nor can the ratings be compared because Ontario uses four categories, whereas three categories are used in Israel.

Despite these differences, in both countries there has been an increase in the percentage of hatcheries showing an improvement in their sanitation rating.

From this, it may be concluded that using a bacteriological technique suitable to the conditions within a country is a very useful means of measuring sanitation in a more precise manner than by the unaided eye. Using a standard technique gives a measure of the situation from year to year.

Summary

Veterinary control and sanitary routine procedures in commercial poultry hatcheries should include: choice of a suitable geographical location to ensure an isolated site; proper hatchery design with separation of major operations; one-way work flow within the hatchery; adequate ventilation of each room; routine cleaning and disinfection; formaldehyde fumigation of eggs, equipment and incubators; and a routine monitoring programme of microbial contamination levels within the hatchery.

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The current status of ca

**The United Nations Conference on the Human Environment,
domestic breeds of livestock that were being endangered.
Programme and FAO commissioned a pilot study in 1974
This article is based on**

by J.J. Lauvergne

The 1974 survey of the cattle breeds of Europe provided a quick tally of those breeds that were likely to be in immediate danger: of the 115 breeds identified, only about 30 were regarded as being outside this category (Lauvergne, 1975). Of course, this simple tally of breeds conceals a more complex reality. It is difficult to compare a widely distributed breed comprising large numbers of animals supported by herdbooks and a computerized selection programme with a localized breed comprising only a few animals with no herdbook. Moreover, some countries have distinguished many breeds among their cattle populations, while others have identified very few. The breeds threatened with extinction are generally the highly localized breeds, or old breeds with a declining reputation. A list of the native cattle breeds of Europe that are in danger of extinction is provided in the table.

J.J. Lauvergne *is with the Animal Genetics Department at the National Centre for Zootechnical Research (Centre national de recherches zootechniques), 78350 Jouy-en-Josas, France.*

Welsh Black bull. (Photo courtesy of Farmer and Stockbreeder**)**

tle breeds in Europe

l at Stockholm in 1972, drew attention to the gene pools of the ing from this Conference, the United Nations Environment he cattle breeds of Europe and the Mediterranean basin. results of the study.

In general, northwestern Europe, which has a temperate oceanic climate and is primarily devoted to dairying, is more severely affected by this wave of change than southern Europe. Italy, Spain, Portugal, southern France and the Balkans are less noted for milk production and are concerned with the raising of triple-purpose cattle for milk, draught and meat.

Reasons for the extinction of breeds

The principal reason for the extinction of many breeds is that the traditional breeds are not productive enough. This handicap occurs mainly among the native breeds, but is also seen in some of the international breeds of Europe that have a lower performance compared with their North American counterparts. Low productivity constitutes the main reason for the inexorable replacement of breeds that is going on in the field of intensive dairy production. Insofar as meat production is concerned, however, it is much more difficult to demonstrate the relative superiority of existing breeds.

Other factors, such as the numbers

Belted Galloway cow. (Photo courtesy of *Farmer and Stockbreeder*)

Native European cattle breeds in danger of extinction

Country	In a relic state	In danger now	In danger in the future	Number of native breeds: In danger	Number of native breeds: not in danger
Austria		Austrian Yellow	Grey Tirolean Pinzgau	3	0
Belgium			Red West Flemish Red and White East Flemish	2	1
Bulgaria	Grey Iskur Shorthorned Rhodope			2	0
Cyprus		Cyprus		1	0
Denmark		Red Danish		1	0
Finland		Finncattle		1	0
France	Ferrandais Froment du Léon Mezenc Blond Pyrenean Villars-de-Lans	Abondance Bazadais Vosgien	Armorican Aubrac Brittany Black and White Corse Flemish Gascony Parthenay Salers Tarentais	17	5
Germany, Federal Republic of	Vorderwälder Hinterwälder Murnau-Werdenfelser	Angeln Rotvich	German Yellow	6	3
Greece	Greek Shorthorn Greek Steppe			2	0
Hungary	Hungarian Steppe			1	0
Iceland				0	1
Ireland	Kerry			1	0
Israel		Baladi		1	0
Italy	Agerolese White Tortona Garfagnana Pisa Pontremoli Sicilian Tarina	Modena Burlina Grey Adige Reggio Rendena Black and White Valdostana	Grey Alpine Maremma Modica Pinzgau Pugliese Romagna Red and White Valdostana	20	1
Malta	Maltese			1	0
Netherlands	Lakenfelder Witrik		Groningen	3	2
Norway	Telemark Raukolle South and Westland Colour-sided Trønder Red Trønder Døle			6	1
Poland		Polish Red		1	0
Portugal		Minho Aroucesa	Barrosa	3	3
Romania	Romanian Mountain Romanian Steppe			2	0
Spain	Leonese Berrenda Cáceres	Pyrenean Zamora	Tudanca	6	6
Sweden		Swedish Polled		1	1
Switzerland	Fribourg		Hérens	2	2
United Kingdom	Belted Galloway Blue Albion British White Dexter Old Gloucestershire Irish Dun Irish Moyled Longhorn Shetland White Park	Beef Shorthorn Dairy Shorthorn Highland Northern Dairy Shorthorn Red Poll	Ayrshire North Devon Galloway Lincoln Red South Devon Sussex Welsh Black	22	5
Yugoslavia	Grey Steppe		Buša	2	1

SOURCE: Lauvergne, 1975
NOTE: For more information on these breeds, see M.H. French, European breeds of cattle. Vols. 1 and 2, Rome, FAO, 1966.

Pyrenean bull. (Photo: I.L. Mason)

of animals within a breed, may also be operative. Modern dairy selection programmes require considerable numbers of breeding cows (at least 20 000) to test the value of sires and a larger number to offset the costs of the tests (a minimum of 100 000 cows). Moreover, changes in agrarian structure can also put out of business the stockmen who are concerned with raising certain breeds, e.g. some Alpine breeds such as the Pinzgau in Austria and the Tarentais in France. In addition, some breeds may die out because the purposes for which they were originally developed may no longer be important (e.g. draught).

An accelerating trend

The displacement of some cattle breeds by others is not a new phenomenon. For instance, during the last century, use of the Shorthorn breed expanded rapidly in the United Kingdom and then in France, Belgium, Germany and Denmark. Similarly, in the early 1900s the Brown Swiss breed (particularly the strains from Switzerland) swamped Italy and ultimately became the leading breed there. However, it has now been overtaken by the Friesian, which is no longer obtained from the Netherlands as most of the sires are imported from North America. Other examples of this kind of displacement are the Ayrshire in Finland and the Normandy in France.

This displacement process has been accelerated through the more effective use of modern facilities and techniques by more technically sophisticated stockbreeders. Thus, communication facilities have been improved everywhere with the development of roads and the more widespread use of automobiles, and more important still, the introduction of artificial insemination has led to the elimination of privately owned bulls. As a result, stockmen must now take whatever semen is deemed most suitable for their use. The implementation of such decisions has resulted in the rapid absorption of several local strains of livestock in Norway and some western European countries.

The replacement breeds

The most significant recent phenomenon in the dairying countries of Europe is the increasing importance of the black and white Friesian, a trend which has been accelerated by the introduction of North American blood into Friesland (the Netherlands) itself. There has also been international consolidation and development of the European red and white and Simmental breeds. Such consolidation clearly offers the only chance of salvation for these breeds; it facilitates the bringing together of large populations to make selection programmes more competitive. Other dairy breeds, such as the Brown Swiss, are also being infused with North American Brown Swiss blood. The development of breeds of a new continental type is also occurring at the boundary be-

tween north and south. These are in direct contrast to the traditional British beef breeds, the Hereford and Angus, which once conquered the Americas. The foremost of the new continental breeds is the French Charolais, which is making good headway in France and other European countries. In the Federal Republic of Germany the Simmental is also very much in vogue. These breeds are being called upon to provide breeding sires for beef production in areas where AI is seldom practised.

Angeln bull. (Photo courtesy of Tierzüchter**)**

Breed replacement and the maintenance of genetic variability

At first sight it might seem that breed replacement of this kind will greatly reduce genetic variability. It is difficult to establish whether this will in fact happen, particularly in view of the lack of objective measurements. The history of animal breeding in Europe reflects the many invasions and migrations that took place, resulting in the development of some degree of homogeneity in the continent's cattle populations. This homogeneity is demonstrated by the presence of the same colour markers almost everywhere. It appears that once a mutation occurred, it had a good chance of spreading widely. Analyses of blood groups and protein polymorphisms show no pronounced isolation between breeds (Rendel, 1967) and no distinct hierarchical kinships (Kidd and Pirschner, 1971). Therefore, it can hardly be concluded that the extinction of a local breed will forever prevent the reappearance of single mutants. Most existing variants will re-emerge in some other breed, perhaps at the other end of the continent, but some will go on existing locally, even if the breed has been assimilated into another. The only difference will be that the associations will be different, possibly creating a problem if the breed were well suited to a given environment.

Tarentais cow. (Photo courtesy of Industrielle - Sartony)

Reasons for preserving endangered breeds

The first reasons that can be invoked for preserving some of the endangered traditional breeds are cultural, and even sentimental. Indeed, as soon as man arrives at any degree of material comfort, he indulges in the study of his origins and recreates the setting in which his ancestors lived. Modern museums are increasingly staging animated shows in open-air museums.

The purely practical reasons arise first from the need to have control populations for measuring genetic progress made by selection. However, this control function is not essential. More important is the fact that developments in animal husbandry often create, somewhat paradoxically, an increased need for hardy native animals, and it is this need that is acutely endangered.

The evolution of European agriculture will increasingly be influenced by the scarcity and cost of labour, and by growing modernization. Under these conditions there will be a tendency to intensify the exploitation of high-return areas such as the rich and easily accessible soils. This could lead not only to the abandoning of mountain pastures, but also to areas of middle altitude reverting to bush, with no benefit to the community. Using these areas for the production of lean meat with minimum labour costs could have several advantages: meat shortages could be alleviated, the environment could be protected (particularly the mountains with their problems of avalanches and the spread of bush), and

a contribution could be made to the supply of ruminants which can be fattened on the by-products of major crops.

In these extensive conditions, such young, lean stock can be produced only from dams of hardy breeds capable of living out of doors all year round and weathering lean spells (particularly in the Mediterranean area), and having a level of milk production just sufficient to nurse the calf. These are all qualities possessed by many of the native breeds that are nearing extinction, and they provide a reason for preserving at least some of them.

Current efforts at preservation

Preservation for cultural or merely emotional reasons is not a recent phenomenon. An example is provided by the White Park breed in the United Kingdom. There are societies today that go on preserving breeds of limited economic value such as the Dexter in the United Kingdom and the Witrik in the Netherlands. This work has been taken over by private demonstration farms, which have developed especially in the United Kingdom, where they are federated into a Rare Breed Survival Trust. Likewise, several regional parks have been established all over Europe on the initiative of associations and governments. These regional parks have taken and developed further the open-air museum — an activity in which the Scandinavian countries pioneered over half a century ago.

The practical utilization of native breeds calls for much larger herds and for an infrastructure much more substantial than that required for their preservation for cultural purposes only. First of all, experiments must be made *in situ* to demonstrate the economic feasibility of raising these breeds, determine the amount of crossbreeding that should be permitted, find market outlets for the animals and provide compensation for the breeders who supply pedigreed dams at a loss as compared with those who fatten and sell the progeny at a profit. Experiments in Sardinia, which have been in progress for over two years, provide good examples of what needs to be done (Casú *et al.*, 1975). The results of the Sardinian experiments suggest that under extensive management conditions, the local females have a greater ability than crossbreds to maintain high reproductive performance and good calf crops, and as a result only a first generation cross with exotic beef breeds makes local beef production more profitable. There have also been other programmed field operations, particularly for the Brittany black and white breed (Quéméré and Bertrand, 1976).

Attention should also be drawn to the many insemination stations all over Europe that have preserved supplies of semen from endangered breeds. In most cases, however, an inventory is still needed.

Finally, from the standpoint of world-wide conservation, it is worth noting the special efforts of the Canadians over the past decade to develop exotic breeds, many of them of European origin, which are to a greater or lesser extent endangered in their native areas. Examples of these are such breeds as the Highland, Lincoln Red, Welsh Black, Devon and Dexter from the United Kingdom, the Tarentais, Salers, Parthenay, Flemish and Gascony from France and the Yellow and Pinzgau from the Federal Republic of Germany and Austria. These have been developed for the same utilitarian reasons as those set out above, i.e. to exploit with a minimum of labour some of the pastoral lands of Canada.

European breeds of the future

There are physiological and economic limits to the improvement of the genetic potential for milk production. Additional quantities of milk come from the feeding of concentrates, which are growing ever more expensive. From an economic standpoint, in some cases it may be preferable to use less expensive feeds and produce less milk. Thus, in addition to the premier dairy breeds, as exemplified by the black and white cattle, there is perhaps room for the less productive dairy breeds as well, which are still economically viable because of their other qualities of meat production, longevity, etc. These breeds are exemplified by the Brown Swiss and the Normandy. Moreover, they have a definite role to play in multi-stage crossbreeding systems for meat production, particularly for ensuring a reasonable level of milk production in the crosses.

It is also probable that the endangered breeds will have a future in beef production. Some, if not all, of the hardy breeds may well stage a comeback in the near future in this sector.

Conclusion

Apparently, considerable progress in the efficient use of the European bovine gene pool has been made in recent years. It is clear that high production *per se* has not been the only objective. There is still room in the modern agricultural economy for cattle breeds whose principal qualities are those that made their forebears the most important domestic animals in the regions in which they occurred: large size and good meat conformation, and ability to adapt to a wide range of climatic and nutritional environments in the temperate as well as hot and cold areas, and also around the Mediterranean basin.

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Current situation and outlook for animal feeds and animal products*

Cereals

The world cereal supply situation has improved substantially in 1976/77 owing to the large increase in production. For the first time since 1971/72, world cereal output is likely to be well above current demand, and stocks are expected to show the first substantial increase since 1972. World cereal production in 1976 is now estimated at 1 345 million tons, 99 million tons (8 percent) above the 1975 level and considerably above the long-term trend value of 1 308 million tons. According to the latest FAO estimate, wheat production in 1976 will reach a new record level of 406 million tons, 52 million tons (15 percent) above the 1975 level. Although most of the crop increase was in the U.S.S.R., where, in contrast to 1975, cereals benefited from very favourable spring/summer weather, wheat production also showed an above-average increase in other parts of the world, particularly in India, Canada and Argentina. Coarse grain output increased by only 8 percent, but production volume, currently estimated at 712 million tons, will set a new record. In contrast to wheat, the expansion in production of coarse grains was entirely due to the record crop of the U.S.S.R. World coarse grain production (excluding the U.S.S.R.) remained at the 1975 level, as increases in North America and Asia were offset by reduced output in Europe owing to drought. Coarse grain production in the EEC countries alone declined from 59 million tons in 1975 to 52 million tons in 1976.

The substantial improvement forecast for grain output in 1976 confirms the prospects of increased consumption at the global level. While demand for food is expected to expand in line with historical patterns primarily linked with population growth, the anticipated growth in animal feed demand is of considerable importance to increased global consumption of wheat and coarse grains in 1976/77. In the U.S.S.R. particularly, larger availabilities will allow for a recovery in cereal feeding after the 1975 setback. In developed market economy countries feed use is expected to increase, but at a somewhat lower rate than earlier anticipated, owing to unfavourable livestock/feed price ratios. In several areas these ratios have made grain feeding unprofitable, a situation which has resulted in a change in composition of rations and generally less grain fattening of livestock. In the EEC larger quantities of wheat will be fed to livestock, but less coarse grains may be consumed owing to lower output, which will probably not be fully compensated by imports and a drawing down of stocks.

While substantially larger availabilities of wheat will reduce trade in that commodity during the 1976/77 season, the volume of coarse grains traded internationally is expected to remain around 70 million tons, close to the 1975/76 level. The reduction in the U.S.S.R.'s coarse grain import requirements will mainly be offset by increased demand in western Europe. Among individual coarse grains, larger imports of maize are expected to balance a decline in the trade of most other coarse grains. However, the barley and oats situation is tight due to smaller availabilities from major exporting countries.

Grain prices in international markets have declined markedly in the recent past. While the fall in wheat prices has been slow but continuous since spring 1976, coarse grain quotations dropped sharply in autumn. Export prices for wheat, maize and sorghum are now down by 27, 11 and 18 percent respectively as compared to the same period a year earlier, mainly owing to changes in the supply estimates for the major producing countries and the lower profitability of feeding grain to livestock, particularly in the United States. Moreover, the margin between wheat and maize prices has also narrowed considerably, especially during September and October, increasing the competitive position of wheat in feed markets. In the coming months, wheat and coarse grain price movements are likely to be influenced mainly by early prospects for 1977 crops, and by the timing and extent of a revival in feed demand. However, the recent increase in United States loan rates ($82.67 per metric ton for wheat) will tend to prevent export prices of cereals from falling to much lower levels.

Oilseeds, cakes and meals

World production of the main oilseeds and oil crops in 1976/77 is expected to show an overall decline from the previous season. Harvests in the developed countries will be distinctly smaller, mainly reflecting the reduced soybean crop in the United States. These declines will be only partly offset by larger crops in the developing countries, particularly in Latin America and Asia and, to a more limited extent, in centrally planned countries. Opening stocks of oilmeal protein, which are relatively large considering the large soybean stocks in the United States, are likely to be drawn down sharply during the season.

The most notable development of the season is the fall of about 7.3 million tons (18 percent) in the latest estimates of the 1976 United States soybean crop, which is now expected to reach only 34.1 million tons. This is the

* As of 22 November 1976

fourth consecutive year that there have been relatively sharp fluctuations in United States soybean production. With near-record carry-over stocks of about 6.6 million tons, this season's total soybean supply will amount to 40.7 million tons, 12 percent less than the record level of the preceding season, but comparable with the record total usage in 1975/76 of 39.8 million tons. The U.S. Department of Agriculture expects total utilization to fall somewhat this season but still exceed supplies from current production, so that the country's end-of-season soybean stocks may be reduced to around 2.3 million tons — the lowest level since the 1972/73 season and less than one month's total requirements. Although as yet no surveys have been made of farmers' planting intentions for next year, the area sown to soybeans in the United States is expected to expand in early 1977, as the maize/soybean price ratio is likely to be more favourable to soybeans than it was a year earlier. Thus, given reasonable weather, a recovery in production is likely. In Brazil, this season's soybean output is expected to expand to around 13.0 million tons, as prospects of continuing favourable market prices are likely to encourage larger sowings. In Argentina, where production has been expanding rapidly in recent years, the crop is expected to exceed the 1 million-ton mark for the first time. In contrast, a distinct reduction is forecast for Mexico.

The world rapeseed crop will be reduced sizably this season. Canadian production will probably be reduced by over 40 percent to only 0.9 million tons — the smallest harvest since 1970 — but total supply and export availabilities will remain ample owing to large beginning stocks. Sunflowerseed production will be larger than last season, though smaller than estimated earlier, as the prospects for a very sharp recovery in the U.S.S.R. crop from the drought-reduced volume of 1975 have been reduced by unfavourable fall harvesting conditions. World groundnut production is currently forecast to marginally exceed last season's level. A record or near-record crop is expected in India, and production in Nigeria and Niger should improve. Cottonseed production is likely to increase, largely as a result of a substantial recovery in the United States.

World output of oilmeal protein from current production is expected to decline by as much as 1.7 million tons (5 percent) from the 1976 record level to 31.4 million tons (protein equivalent) in 1977. This change mainly shows to what extent variations in soybean production influence the meal protein sector, as soybeans now account on average for nearly 60 percent of total supply in protein equivalent.

Such a level of world output would be very markedly below the level suggested by the extrapolation of the long-term trend. However, the large opening stocks of soybeans partly offset the reduced output, particularly in the United States. Although requirements for protein meals will probably be smaller than in the preceding season, they are likely to remaing strong, reflecting the continuing improvement of economic conditions, and are expected to exceed supplies from current production, so that stocks will have to be sharply drawn down this season. United States export availabilities of soybeans and meals are officially expected to be lower than in the preceding season. As about 1.5 million tons of this season's soybean crop are already contracted for by the U.S.S.R. (compared to 0.3 million tons in 1975/76), and a guaranteed level of supply to Japan of at least 3.0 million tons has been reported (as against exports of 3.2 million tons last season), the availability of United States supplies for other countries is likely to be smaller this season. However, Brazil's exportable supplies of soybeans and meal are expected to increase. Demand will, however, be tempered by prices, which are expected to average above those in the preceding season. Comparatively less tight availabilities of grains for livestock feed this season are likely to result in grain/protein price ratios which should encourage an expansion in grain use at the expense of protein meal.

The prospects of relatively tight supply/demand situations in the 1976/77 season, more pronounced in the case of oilmeal protein than in that of fats and oils, have affected the price levels of these two groups of products in past months. International prices of soybeans and meals, after remaining at relatively low levels during the last quarter of 1975 and the first quarter of 1976, rose significantly between May and July, reflecting prospects of a marked reduction in the United States soybean crop following reduced plantings and fears (subsequently confirmed) of possibly reduced yields owing to unfavourable weather conditions, heavy U.S.S.R. purchases in early July, and probably some speculative interest. However, price rises levelled off in late July.

• Milk and milk products

The rise in world milk output is likely to slow down substantially in 1976/77, and consumption of milk products is expected to increase, thus reducing stocks, especially of skim milk powder. Production is expected to recover in the U.S.S.R., reflecting a considerable improvement in the feed situation and some increase in cow numbers. Output in the United States will continue to expand, though probably not at the very high rates registered in recent months. A moderate expansion of production is anticipated in the developing countries. Production in eastern and western Europe, Canada and Australia is expected to decline or level off. In Europe and Australia dairy farming will continue to reflect the effects of the 1976 drought which reduced winter fodder supplies and led to additional slaughterings of dairy cows. At the same time, the relationship between prices of milk and commercial feeds has been changing to the disadvantage of dairy farmers in western Europe. The slowing down of milk output has been accentuated in some developed countries, notably Australia, Austria, Canada and Switzerland (which produce milk in excess of commercial market requirements) by specific restrictive measures. Similar action is being considered in the EEC. On the whole, in 1976/77, prices to milk producers in surplus-producing developed countries have not been raised as much as in previous years. Moreover, because the increase in consumption of milk products, especially cheese, is expected to gain momentum with general economic recovery, less milk will be available for the manufacture of butter and skim milk powder. A considerable part of the skim milk output of Australia and New Zealand will continue to be diverted from the production of skim milk powder to casein manufacture. At the same time, developed countries will continue to encourage feed use of liquid and dry skim milk. Food aid in milk powder to the developing countries is expected to continue on a substantial scale, with the EEC and the United States remaining the principal donors. Food aid availabilities in 1976 were well over 250 000 tons, and supplies should remain ample in 1977. Lower production

and increased consumption will thus result in a reduction of world skim milk powder stocks from their record 1975/76 level of over 2 million tons. Butter stocks have not yet reached such excessive levels. However, as demand for butter is expected to decline in many developed countries, stocks will not be reduced significantly in 1976/77 unless consumption is stimulated by special new measures. Demand prospects are particularly unfavourable in the United Kingdom, which has so far been the largest butter-consuming developed country. Consumer prices in the United Kingdom have been raised particularly sharply, reflecting both higher prices to milk producers and reduced government subsidies. The phasing out of consumer subsidies has also affected demand for liquid milk and cheese in the United Kingdom. Milk output should recover in Europe after the beginning of the 1977 grazing period, provided weather conditions remain normal. The measures to curtail milk output that have been launched or are envisaged do not appear to be sufficient to adjust production to the level indicated by commercial requirements. This applies in particular to the EEC, the world's principal producer, exporter and stockholder of dairy products. Thus, although policy action to curb milk output may be intensified, costly measures to encourage domestic consumption and exports by developed countries may have to be continued for some time to come. Such measures would leave little scope for an improvement of prices in international dairy trade, which had fallen substantially by 1976.

Meat

The contraction phase of cattle cycles continued in most major beef-producing countries throughout the third quarter of 1976. Cattle slaughterings rose in the drought-stricken regions of western and eastern Europe and Australia during the summer months. In the United States cattle slaughter also rose substantially in the summer, depressing cattle prices. As a result of the drought, EEC intervention purchases of beef were stepped up in the third quarter of 1976 and were extended to cow beef in drought-affected regions of the Community. A private storage scheme was also introduced. In August 1976, public intervention stocks in the EEC stood at 340 000 tons (carcass meat equivalent). In order to help farmers cope with the drought, several countries introduced special measures to encourage cattle owners to not deplete their breeding herds, or, as in Australia, made payments to farmers for livestock destroyed because of drought. In 1976 beef production is estimated to have declined by 3 percent in the EEC and most other European countries because of the lower slaughter weight for animals. But beef output is expected to rise substantially in North America and in the major Southern Hemisphere exporting countries. In western Europe and North America pigmeat production is moving toward its cyclical peak in 1977, with the bulk of the increase having taken place in 1976. Expansion of output could, however, be slowed down because pig/feed price ratios have become less favourable in recent months. In the U.S.S.R. pigmeat output during the first seven months of 1976 in the socialized sector was a quarter below the corresponding period in 1975. The downturn in pigmeat production was also pronounced in most eastern European countries and Yugoslavia. Trade in beef and veal in 1976 continued to be affected by the restrictions imposed on imports by many western European countries and Japan, the substantial stocks of frozen beef in the EEC, the abundant supply of pigmeat in most beef-importing countries and stagnating consumer demand. In Italy, continuation of the import deposit scheme and the tax on payments in foreign currency have made meat imports expensive. In the United States, import quotas were applied in the fourth quarter of the year when it became evident that potential aggregate imports of meat subject to the Meat Import Law would exceed the 1976 quota quantity of 508 485 tons. Nevertheless, actual 1976 imports were allowed to exceed this quantity by 50 802 tons. Trade in beef and veal in 1976 is expected to recover from the low 1975 level. However, the U.R.S.S.'s imports remain a major unknown factor. In leading importing countries reduced beef output in 1977 could, if accompanied by economic recovery, increase the import demand in late 1977 and 1978. In the short term, however, large frozen beef stocks and high output of pigmeat are likely to continue to depress meat prices, and import requirements in western Europe and North America are expected to be rather low.

Post-graduate programmes in animal health and production in tropical Australia

The James Cook University of North Queensland in Townsville, Australia offers several post-graduate programmes in animal health and production in tropical Australia which are designed to meet requirements for the advanced training of veterinarians and other scientists.

M.Sc. course in tropical veterinary science. This 12-month course is described in World Animal Review No. 17.

M.Sc. and Ph.D. research programmes. Students are accepted for research work in several fields including the pathology of livestock, virology, immunology, helminthology, ruminant nutrition, reproductive physiology and animal breeding. Applicants, who may be graduates in veterinary science or related disciplines, can be considered for acceptance at any time.

Intensive course in cattle husbandry and ranch management in the tropics. An eight-week course is presented annually in March and April provided there is a sufficient number of applicants. The course is available to veterinary and agricultural graduates or diplomates. Extensive use is made in field studies of the variety of tropical environments in North Queensland ranging from semiarid scrub and grassland to intensively stocked improved pastures in high rainfall or irrigated areas. Within these regions there are several different animal production and pasture utilization regimes which provide facilities for the training and research programmes of the School. Contributions to seminars and field and research programmes are made by scientists from the Queensland Department of Primary Industries, the Commonwealth Scientific and Industrial Research Organization and other institutions.

Applications and requests for further information should be sent to the Registrar, James Cook University of North Queensland, Townsville, Queensland 4811, Australia.

Australian graduates are eligible for Commonwealth Postgraduate Course Awards.

XXth International Dairy Congress

This Congress will be held at the Centre international de Paris, Porte Maillot, Paris, from 26 to 30 June 1978. A preliminary announcement issued by the Congress Secretariat states that the subjects chosen for inclusion in the programme will be of interest to scientists, dairymen, economists, businessmen and regulatory agencies. Geographical, climatic and social aspects will be studied.

The scientific subjects to be developed in depth are: the nutritional value of milk; factors governing the acceptability of dairy products; food habits and the consumption of dairy products, and new technological processes, particularly those relating to economy in the use of energy and water, and protection of the environment.

In addition, consideration will be given to milk production (especially in relation to the composition and quality of milk), bacteriology and biochemistry of milk and dairy products (particularly laboratory methods for assessing the composition and bacteriological quality of milk and dairy products), and specific aspects of milk, cheese, butter, milk powder, cream, whey and other dairy products. Special attention will be given to new products.

Among the economic and commercial subjects, the following questions will be considered in detail:

- How to develop milk production in different types of agriculture based on the breeding of cows, buffaloes, goats or sheep;
- How to harmonize the relations between production, manufacturing and consumption through international economic cooperation as a means of balancing the markets, by meeting the needs of different kinds of consumers, particularly children and adolescents, especially in developing countries, and by protecting the best traditional local products which represent the pride of international dairying.

Congress sessions will include lectures and discussions. Contributions dealing with subjects in the programme will be published in a volume and distributed to participants at the opening of the Congress.

The official languages will be French, German and English. Simultaneous interpretation will be provided.

Visits to dairies, dairy farms, goat and sheep farms, research laboratories etc. will be organized. There will also be a social programme for associate members. In addition, pre- and post-Congress excursions will be organized to different regions of France.

Further information may be obtained from the Congress Secretariat, Congrilait, 50 rue Fabert, F-75007 Paris, France.

NEW BOOKS

Dermatophilus infection in animals

Edited by D.H. Lloyd and K.C. Sellers. Academic Press, London, New York, San Francisco. 1976. 332 p. Price: £7.00, U.S.$17.25. (In English)

The name of the disease produced in cattle and many other animals, man not excepted, has been carefully omitted from the title of this informative and stimulating book. It represents the proceedings of the first international symposium (held in Ibadan, Nigeria from 25 to 28 June 1973) on what is known as "contagious dermatitis" — streptothrichosis in cattle, and lumpy wool or strawberry foot rot in sheep. Recently, several efforts have been made to replace these old-fashioned names with the more sophisticated "dermatophilosis." However, it may be better to maintain an old name rather than embark on a new nomenclature in view of the vacillating names of the parasite. The name *Dermatophilus congolensis* deserves consideration in its own right, and so does the term "dermatophilus infections" in animals and man.

The proceedings contain the considered views of many well-informed scientists who assembled in a country where the disease is a problem. They discussed the epidemiology of the disease in Africa, Europe, the Near East, North America and South America; the skin of cattle as a suitable environment for *D. congolensis*; the lesions and the immunological reactions it produces; biology, treatment and prophylaxis; and the economic consequences of streptothrichosis. The editors are

Protein and nutrition policy in low-income countries

Francis Aylward and Mogens Jul. Charles Knight & Company Ltd, 25 New Street Square, London EC4A 3JA; Sovereign Way, Tonbridge, Kent TN9 1RW. 1975. 149 pages. (In English)

The book is based on a report prepared for the Protein-Calorie Advisory Group of the United Nations System, a body sponsored by several United Nations agencies and the World Bank. It deals with aspects of protein-calorie malnutrition, with particular reference to protein deficiencies in human nutrition in developing countries.

It is divided in two parts, of which the first deals with "proteins, protein deficiencies and the sources of food proteins," and the second with "lines of action" suggested as the remedies needed to effectively improve human nutrition in the needy countries.

In the second part of the publication the authors suggest in four chapters national food and nutrition policies, action within low-income countries, the contribution of industrialized countries (mobilization of scientific and technical resources) and the contribution of United Nations agencies, national technical assistance agencies, international foundations and voluntary bodies. Ways in which members of the international community could contribute to solving the problem of hunger and malnutrition are set out.

This book presents updated views on rational human nutrition and the present status of malnutrition in low-income countries that will be of interest to those involved in the development of food production in various fields of agriculture, animal production, food processing and research.

W.B.T.

to be congratulated for bringing together all this material. They have also presented a very interesting and concise biography of René Van Saceghem, who named the disease and described the causative organism in 1915. The proceedings end with a non-conclusive discussion on the name of the disease. It is unfortunate that three years elapsed between the meeting and the publication of the proceedings. But since little substantial progress has been made subsequent to the Ibadan meeting, the papers and discussions presented in this book will be of special interest to those concerned with veterinary and human medicine, biology (mainly the biology of actinomycetales), the economics of livestock and various aspects of pathology.

R.V.

Commercial processing of poultry

G.H. Weiss. Noyes Data Corporation, Park Ridge, New Jersey, London. 1976. 254 pages. Price U.S.$32, including packing and postage. (In English)

Poultry meat has a low calorie and low cholesterol content. Its relatively low market price makes it attractive to the consumer. The United States leads the world in the consumption of poultry meat (108 kg per caput in 1973).

During the last 25 years, poultry meat production has been developed on an industrial basis through the broiler industry. This started first in the United States. The final product of this industry — the broiler or its components — is subject to processing in order to preserve or improve the quality of the meat for human consumption. A large number of persons are involved in this processing and, of course, many people enjoy the products. Many countries, and especially the United States, have carried out innumerable studies in an effort to produce a nutritious, low-calorie food at a relatively low, yet profitable, price.

Based on patents registered in the United States, this publication is very useful in that it provides a wealth of comprehensive, up-to-date scientific and technical information on the commercial processing of poultry. Its eight chapters are concerned with preservation, chilling and freezing, enhancing palatability, stuffed products, moulded and compressed rolls and loaves, batter-coated products, special cooking procedures and products, and poultry concentrates and flavours. At the end of the book are three indexes (company index, inventor index and United States patent number index).

This is the first time that a comprehensive bibliography on the commercial processing of poultry has been published. It coincides with the increased attention being paid to the improvement of this area of human nutrition.

The book serves a double purpose in that it provides detailed technical information and can be used as a guide to the United States patent literature in this field. Many of these patents are being utilized commercially and offer opportunities for technology transfer. The many technical possibilities that may open up profitable areas for research and development are clearly set out and allow the reader to obtain a sound background before launching into research in any selected field.

The book is recommended for people dealing with the commercial processing of poultry. It would be of use to both the practical worker and the researcher.

T.G.V.

Correction: *World Animal Review* No. 20, page 39.

In the article by J.B. Owen (*Complete diets for dairy cattle*) Table 2 should read:

Table 2. — Comparison of winter feeding of conventionally fed and self-fed groups of dairy cows

	Conventionally fed group (25 cows)		Self-fed complete diet group (25 cows)			
	Early lactation (daily allowance)	Late lactation (daily allowance)	Early lactation: Fresh weight	Early lactation: Dry matter	Late lactation: Fresh weight	Late lactation: Dry matter
Diet composition	*Kg fresh weight*		*Percent*			
Grass silage	18-20	18-20	39	35	40	33
Swedes	16	16	30	12	28	10
Distillers' grains	11	11	21	21	21	19
Barley	7	5	8	27	7	23
Protein concentrate according to yield in parlour			2	5	1	5
Straw	—	—	—	—	3	10
Metabolizable energy content (MJ/kg DM)				10		8.5
Performance during trial period						
Average daily yield	*kg*		19.5		18.6	
Concentrates (barley + protein concentrate)	*kg/cow*		1 410		939	
Calving to conception interval	*days*		78		73	
Weight change	*kg*		+11		+11	

New concepts of cattle growth

Roy T. Berg and Rex M. Butterfield. Sydney University Press, Press Building, University of Sydney, NSW, Australia. 1976. 240 pages, with diagrams and tables. (In English)

This book owes its origin to a period of sabbatical leave taken in Australia by Roy Berg, a professor of animal genetics at the University of Alberta (Canada), when he realized the value of the anatomical techniques used by Rex Butterfield, a professor of veterinary anatomy at the University of Sydney, for the assessment of progress in genetic improvement in cattle. The association between the two authors led to the accumulation of a large volume of information based on an analysis of total dissection data obtained by a single dissection technique in both Australia and Canada. In this book the authors have brought together findings from their own studies and from other published and unpublished work in an attempt to provide a new appreciation of the process of growth and an understanding of its importance to cattle production.

The book's eight chapters deal with cattle growth and beef production, growth patterns of muscle, fat and bone, changes in the chemical composition of cattle during growth, muscle growth patterns in steers, factors affecting muscle growth patterns, growth and distribution of fat in cattle, growth of muscle of cattle relative to that of other species, and methods of measuring and predicting carcass composition. The influence of nutrition, breed and sex is well described and used to develop functionally sensible concepts of growth.

This book is likely to become a standard text on growth and development of cattle for use by students of animal and veterinary science in all parts of the world.

P.M.

Recent FAO documents

Research on tick-borne diseases and their vectors. Report of the FAO Expert Consultation held in Rome, 6-8 May 1975. 1975. MR/F9635. (English)

Summarizes the discussion and recommendations of the Consultation relating to characterization of tick-borne parasites, epizootiology, treatment, immunity and immunization, biology and population dynamics of vector species, vector control, and dissemination of information.

Research on trypanotolerance and breeding of trypanotolerant animals. Report of the First FAO Expert Consultation held in Rome, 16-19 March 1976. 1976. M/K1614. (English and French)

Reviews what is presently known about trypanotolerant breeds of livestock, the biological bases of trypanotolerance and the epizootiology and pathology of trypanosomiasis in trypanotolerant animals, and details current and proposed research and development programmes. Includes summaries of working documents presented at the Consultation and a bibliography on trypanotolerance and trypanotolerant breeds of livestock.

Pilot study on conservation of animal genetic resources. 1975. MR/F7974. (English)

This report, prepared as part of a cooperative project of the United Nations Environment Programme and FAO, reviews the work done, gives a summary of conclusions, and presents recommendations for immediate and short-term action to be taken to conserve breeds in danger of extinction, and a long-term programme to improve genetic and practical knowledge in the field. Includes surveys of disappearing cattle breeds in Europe and the Mediterranean basin and endangered livestock breeds throughout the world.

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